COMPUTERS
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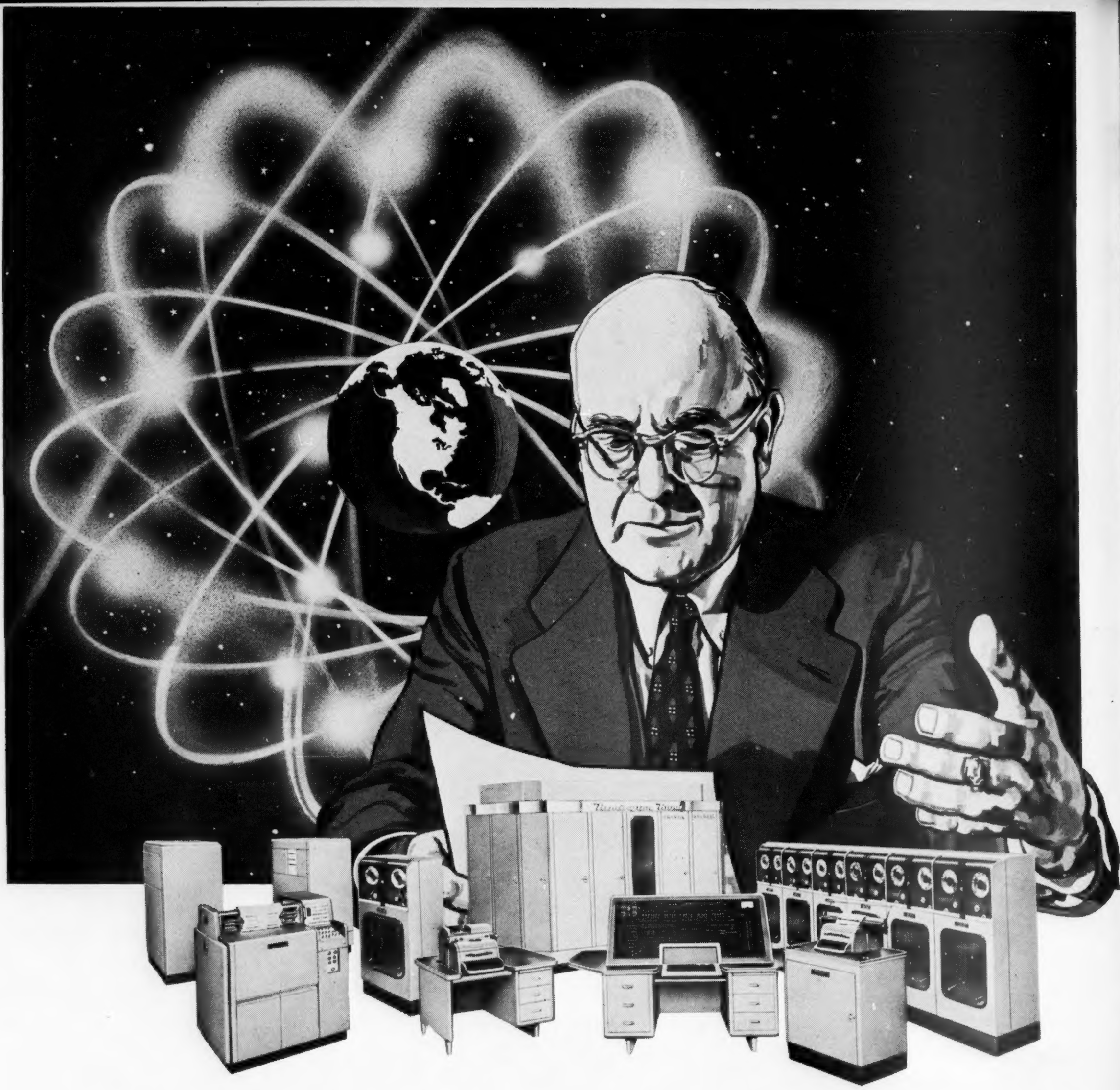
AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL



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COMPUTERS AND AUTOMATION

CYBERNETICS ♦ ROBOTS ♦ AUTOMATIC CONTROL

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THE EDITOR'S NOTES

THE COMPUTER DIRECTORY

The June 1956 issue of "Computers and Automation" will be the second issue of "The Computer Directory". It will have three parts: Part1, "Roster of Organizations in the Computer Field"; Part 2, "The Computing Machinery Field: Products and Services for Sale"; Part 3, "Who's Who in the Computer Field". For more information about entries, etc., see the notice in this issue on the Computer Directory.

ADDRESSES OF GIVERS OF PAPERS

At the Association for Computing Machinery meeting in Philadelphia, in September 1955, over 120 papers were given. In the November issue of "Computers and Automation", we printed the titles and abstracts, using the meeting program and copying by photooffset. Since the program did not show the addresses of the givers of papers, we received a number of requests from readers of "Computers and Automation" asking how they could write to the speakers. We found out that the addresses had been dittoed by Professor John P. Nash, chairman of the Program Committee of the Association for Computing Machinery, and he has kindly given us this list for printing. In this issue, therefore, we print the names and addresses of persons giving papers at that September meeting.

We hope that future programs of meetings will show enough of the address of each person giving a paper, so that persons interested in papers can write to the givers of papers, in the interim before publication, and obtain more information about the paper than is given in the abstract.

MAILING LIST OF COMPUTER PEOPLE

For the mailing of the Western Joint Computer Conference for the meeting in San Francisco, February 1955, we provided about 11,500 names of computer people, produced from I B M punch cards. The slips were made by an IBM 407 Tabulator and enclosed in a window envelope. There are undoubtedly errors on these cards: if the slip you received contained an error in your name and address, we should greatly appreciate your sending us the erroneous slip, with the correction marked. If that slip is no longer available, but you remember that it showed a wrong address, send us your correct address, marking it AP so that we know this address is to match up with the mailing list used for "advance programs" of meetings.

This mailing list of computer people is being maintained by "Computers and Automation" with the help of the Joint Computer Conference. This list is not released for advertising purposes: it is used (1) by us from time to time to improve our "Who's Who in the Computer Field", and (2) by the Joint Computer Conference from time to time to send out notices of their meetings. Other similar organizations may of course use it, at small costs, for mailing out meeting notices and advance program mailings.

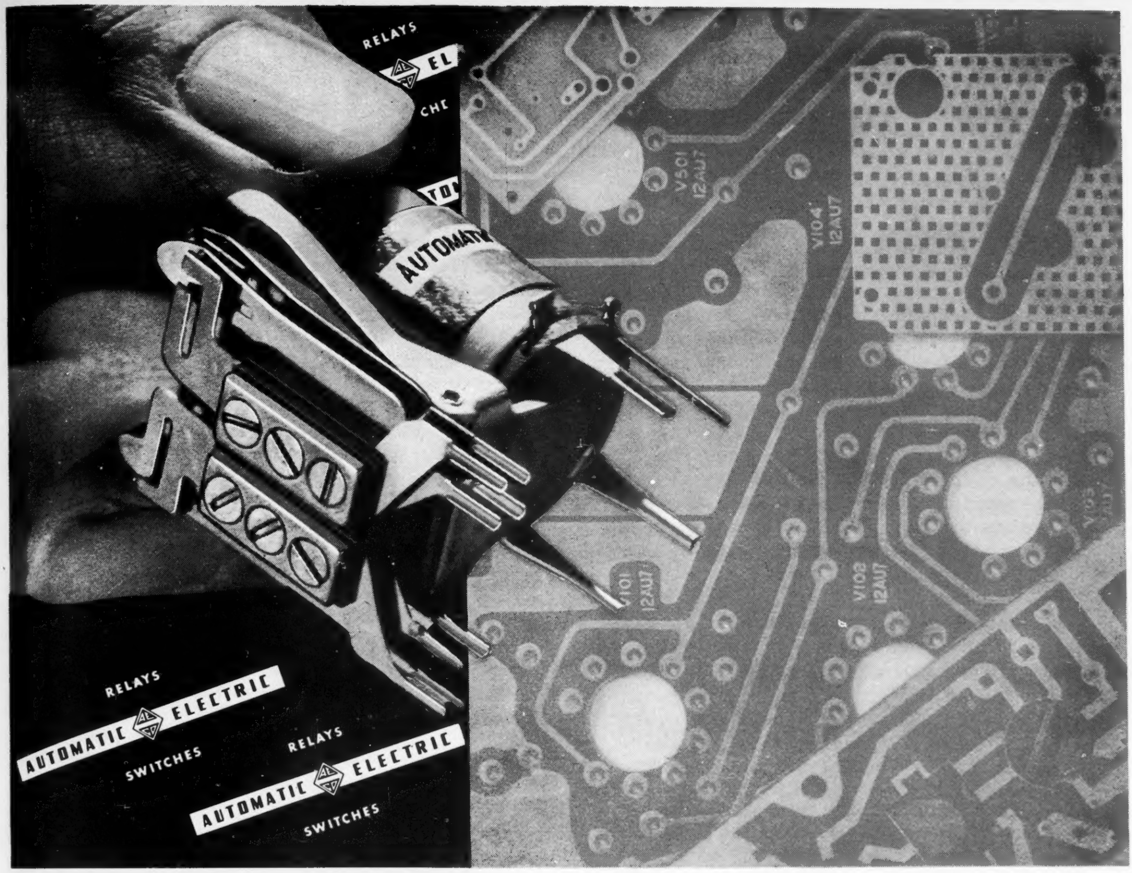
CORRECTIONS

In the September issue of "Computers and Automation", on page 17, after the name of the author (I. Asimov), and before the start of the story ("Franchise"), there should have appeared the following note: (A longer version of this story appeared in the August 1955 issue of IF magazine; copyright, 1955, by Quinn Publishing Co., Inc.)

In the October issue of "Computers and Automation", on page 30, in the "Who's Who" the name Burton Grad, Production Specialist, was incorrectly listed as Burton Brad. We regret this unfortunate error.

INDEX OF NOTICES

Address Changes: If your address changes, please notify us giving both old and new addresses, and allow three weeks for the change.



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The Function of Automatic Programming for Computers in Business Data Processing

R. J. ROSSHEIM
Supervisor, Industrial Programming Research
Remington Rand, Division of Sperry Rand Corp.,
Philadelphia 3, Pa.,

(Presented before the Association for Computing Machinery, Philadelphia, Pennsylvania, Sept. 14 to 16, 1955)

This paper is concerned with the role that automatic programming systems for large, general-purpose computers might play in the application of these equipments to business data-processing problems. My definition of automatic programming for the purpose of this discussion is extremely broad, including any programming system which is capable of substantially reducing the time and effort now required to program the machines. The definition of automatic programming certainly includes the concept of relegation of purely clerical portions of machine coding to the computer itself, but it is not limited to this concept.

It is hoped that this paper will stimulate interest and encourage effort in developing more advanced automatic programming systems for business use.

Training

I shall start with the training phase which normally precedes the computer installation. I shall make the assumption, which is now virtually a cliche, that the company embarking on the computer venture has decided to train its own people in the use of the equipment, rather than to educate trained programmers from outside the company in the endless detail of its data-processing procedures. The immediate problem is to train people in the use of a machine which far transcends in terms of flexibility, power, and speed anything to which they might be accustomed. Frequently, we require that the people selected have superior ability in overall system planning since we expect the equipment to have a sizable impact on our procedures, and yet the first thing these people must do is submerge themselves in the swirling multitudes of electronic binaries which must eventually be arranged, bit by bit, to control the execution of the payroll accounting function, or the like. The basic problem is that the equipment when delivered has built into it only one basic ability, that being the ability to interpret a certain language which is the instruction code of the machine. This code certainly is logically complete and can be adapted to meet every conceivable requirement of the user. At the same time, it is elementary, or stated another way, it is a language of monosyllables. An indicator of the size of these elements is the revelation in more than one computer installation that it requires many tens of thousands of these elementary machine instructions to describe completely the payroll accounting function.

The training problem would be considerably reduced if the equipment were able to interpret the everyday language of the procedure analyst and to translate the meaning so conveyed into its own binary arrangements. This is, of course, an ideal. It is fundamentally dependent on the existence of such a language, assuming also precise meanings and universality. The concept of such a language is not so new, nor so ideal, that there are not even now some research groups working in this area. I believe the objective can be stated as raising the level of machine comprehension to the language of the user, rather than forcing him to adopt monosyllabic machine talk.

The ability to program would become a relatively simple operational tool similar to data flow charting, or procedure manual writing. It would permit the procedure analyst or his counterpart to spend more of his time taking the broad view of data flow through a system, and to concentrate on the objective of good system design.

I think that very few of the people selected to work in this field will be interested in becoming professional programmers; so the requirement is to make the equipment available to such people on a basis which is consistent with the other tools of their trade.

I am suggesting that the objective of automatic programming techniques during the initial training stages might be the development of a relatively simple pseudo-code which would employ to whatever extent now possible, the language of the user. The computer would be enabled to translate programs written in this language into the elementary machine codes. The immediate effect should be that trainees could learn in much less time to write usable programs. At the same time the tendency would be away from creating highly-trained specialists and toward the development of part-time or temporary programmers from those who are experts in the jobs which are to be prepared for the machines.

I should note that, although there is not to my knowledge a pseudo-code system for business applications, an experiment involving the same principle was successfully carried out by

the Whirlwind computer group at M.I.T. two years ago. The so-called Summer Session Computer was a programmed modification of Whirlwind which permitted the principles of programming to be taught to a student group of varied interests and backgrounds, based on a pseudo-code which was easily learned and applied.

Approximation and Experimentation

Next, I will consider the role of automatic programming in the time consuming and costly preparation of data-processing procedures for a computer system. Before discussing automatic programming per se in this regard, I will talk about programming procedures for commercial work.

First, the concept of approximation. This approach is suggested by the tremendous amount of detailed information which must be gathered, analyzed, organized, and finally programmed into a computer data-processing procedure. Information may come from procedure manuals, rules, and regulations which are sometimes subject to interpretation, or from informed, but sometimes inarticulate clerical personnel. As a result of the nature of the information and its sources, a fundamental requirement of programming cannot be met; that is, the "problem", or job, cannot be completely predefined. Therefore, programming must often begin with incomplete or incorrect information, and the first program is necessarily merely a first approximation. Frequently, voices which were silent during the survey and fact-finding visits, are quick to provide the necessary criticism when the first approximation misses the mark. Then the hard realities begin to be revealed, the neat flow charts spread out, developing all manner of intricate networks, and the programs start to overflow available storage. If I have conveyed the idea at all, it should not be necessary to say that the second approximation is not final, nor the third; but finally an acceptable, if not perfect, version is developed which comprehends everything of major importance as well as most minor details. The fact is, although the approximation technique described above may not be consciously employed, it represents a good description of what actually happens.

Another approach, which is the other face of the same coin, involves the idea of experimentation. Whereas approximation methods convey the idea of working gradually toward a single correct and best procedure, the experimentation viewpoint acknowledges the fact that our analytical tools for designing electronic data-processing systems are extremely primitive, so that our current progress is largely the result of trial and error methods. Currently, it is too costly to try a number of different approaches to the same application, if this involves programming a second time. Moreover, the systems we design are likely to be very conservative in order to reduce the chance of having to make major changes. Thus, we miss many opportunities to learn more about how to use this new equipment as the pressure of schedules forces us to settle upon procedures which may be far from optimum.

If these ideas are reasonable, involving as they do the use of approximation techniques and experimentation in the design of commercial data-processing programs for computers, automatic programming can play several important roles. In fact, it is apparent that any systematic approach to programming which would assist in the process of going from one approximation to the next without recoding would reduce the total amount of coding considerably.

Flow Charting

I shall now discuss the various phases through which an application or job must pass before a working program is ready for the computer. It is significant, I think, that problems which have arisen in all of the areas could be solved, either wholly or in part, by one or more of the techniques which fall within my definition of automatic programming.

First, let us consider flow charting. Apparently the flow chart, in a multitude of forms, is the most easily adapted and universally accepted method of describing data-processing. The need is for some way of arranging great masses of detail in such a way that we can see both forest and trees at the same time. Typically we proceed from the broadest level of flow charting which outlines the entire application, down through several successive levels, each adding detail, until in some cases we draw charts which virtually indicate the machine instructions required to perform each block on the chart. Such charts, I have heard it said, could be handed to people who have been trained in the computer instruction code, and they could translate the detailed flow chart into a machine program without using any discretion or judgment. They would perform a clerical function. But why not let the computer itself perform the clerical function of translating detailed flow charts into sequences of machine instructions? I believe that the translation of flow charts into machine codes should be a primary objective of an automatic programming system for business data-processing.

Some of the problems in trying to do this are very challenging. First, we need a "flow-chart-to-digital-computer" converter so that

we can feed the flow chart into the computer. Second, any auto-programming system I can conceive of must work from a very specific "language" that must have all the precision of the machine code, while at the same time adapting itself to the requirements of flow charts, of programmers, and of the applications. I will not stop to enumerate other problems in accomplishing what I have suggested, but perhaps I should make one point clear. It is certainly true that many programmers leave the flow chart behind in the pressure to write machine codes, but remember that what I am suggesting should replace the writing of machine codes. I acknowledge, too, the fact that often when the programmer and clerical coder are the same person, as is more often the case than not, the detailed flow chart is omitted entirely. However, I would expect that as we learn more about the elements of data-processing, we will be able to build auto-programming systems capable of interpreting higher level flow charts, wherein each block represents a functional subroutine containing many machine instructions, rather than just one or two. My feeling is that the first step in this direction is the really difficult one.

Coding

In the conventional sequence, after flow charting comes coding, and since flow charting is not going to replace coding tomorrow, there is considerable work for auto-programming in the coding phase. It is in this area where currently some encouraging progress is being made. I shall merely mention some of the contributions that auto-programming systems can make to business data-processing applications.

First, automatic programming systems can assist in standardizing the programs by specifying the form of the coding, and by supplying a library of subroutines which are copied into programs wherever they apply. Second, as more is learned about recurrent subroutines, libraries of such routines can be developed, and programs can be written in a shorthand pseudo-code, thereby avoiding duplication of coding which has been written before, and consequently reducing the amount of new coding in each new program. Third, the tedious bookkeeping jobs associated with the preparation of finished coding can be wholly or partly relegated to the computer, thereby releasing the programmer to concentrate on the design of a complete and efficient computer procedure, rather than burdening him with coding details.

The fact that not enough is now known about the technical language of data-processing should not discourage the development of initial automatic coding systems. As certain processing functions are defined, standard routines can be written and pseudo-codes invented to call up these routines. However, now and for some time to come, any automatic coding system must accept conventional machine coding as well as pseudo-coding.

Another improvement in programming procedures which can be designed into an automatic system is the ability to have several people work on different parts of the same program without the usual problems of communication.

Program Checking or Debugging

After the program has been prepared, it must be checked or debugged, which frequently requires many additional man-hours and machine-hours. Much of the abusive language concerning the cost of application of computers is directed at this stage of the operation. Basically, two kinds of programming errors account for the effort which is expended at this point. First, there are the simple-minded errors resulting from poor or incomplete record-keeping during the process of coding, or from slight misunderstandings of the way in which the equipment operates, or the typographical kind of error. Second, there are the logical errors which may result from incorrect translation of the flow chart, or failure of the programmer to consider certain cases or combinations of cases. It is very easy to sympathize with the programmer for he must have the ability to work in minute detail and, at the same time, keep in mind the complex interrelationships within the entire framework of the program. Putting sympathy aside, however, there is a pressing need to improve methods of programming in order to avoid some of the errors, and at the same time to provide for efficient methods of error-correction. This means that the automatic programming system does not stop functioning with the production of the first "approximate" program. Systematic error correction techniques should be provided to assist correction of all kinds and levels of errors. Some study should be made of debugging procedures considering typical business installations, the operating characteristics of the equipment, and the requirements of the programmer.

The availability of an automatic programming system may avoid many of the pitfalls which arise in the debugging stage. For instance, if the approximation idea is utilized, it is conceivable that a programmer would prepare a routine concerned only with the main flow of data, knowing at the time that there were many loose ends. By debugging the partial routine he has the advantage of working with a smaller, less complex program initially. Once this is checked out, it should be relatively simple to control and isolate errors

as additional routines are added to make the procedure complete. Here too, automatic programming techniques would substantially reduce the time and effort, since it should be possible to blend in new subroutines and correct existing routines, taking best advantage of the parts of the program which are complete, correct, and tested.

With respect to the testing phase, the most important contribution an auto-programming system could make is the reduction in overall elapsed time required for the first approximation. It is vitally important to reach at the earliest possible date the first check point where the critical look is taken and the information feedback is activated. No degree of accuracy and no amount of care can replace the first test in turning up weaknesses in the program or procedure.

Testing

Once the program has been debugged to the point where it is operable, it must be checked against the other contingent parts of the system. Actual operating conditions and data must at least be simulated. How heartbreaking are the programming failures at this point! Yet, this often is the first real checkpoint in the sense that some actual data are processed, and the programmed procedure is more easily checked to see whether it fulfills all the requirements between input and output. This is the first approximation. Since it is very inconvenient to check coding itself, it is necessary to process input and to produce output, both of which must be referred to the people in the business who either originate source documents or use the reports. These are the important critics of the procedures. They are the inspectors at the end of the production line. Since the procedure was originally set down and the initial flow charts were drawn there has been considerable dead-reckoning. Using conventional methods of programming and coding, there has also been considerable time. Now the feedback of information begins, and the procedure begins to be refined. The second, third, and successive approximations are written, each requiring repetition of some or all of the preceding steps.

Corrections, Modifications, Revisions

After the results of the first approximation have been checked a steady flow of modifications, corrections, and additional routines must be merged in with the original program. All too often the delicate balance is upset by these changes, and succeeding debugging is even more difficult than the original. Hopefully, an automatic system would permit new parts of the program to fit into the existing organization, without the complete recoding which conventional methods would require.

Related to the foregoing is the idea of revision of the program, at some later date, to provide for changes in the procedures. It is a mistake, I think, to regard business applications as static. Just as business itself is dynamic, the data-processing requirements are constantly changing, and it would seem reasonable to rate a data-processing system in terms of its ability to respond to changed conditions. Automatic coding could be the key to this ability.

This might be an appropriate point to mention another problem. When a programmer is in the midst of a particular routine he can follow the coding he has written quite easily, but let him move on to another coding assignment, and after a week he will have largely forgotten the first program. It is almost as difficult for him to trace through the coding as for someone who has not seen it before. Any programming system should provide a method for carrying along verbal descriptions of the functions which the different parts of a program perform. If this could be tied in to the flow chart, subroutine by subroutine, together they would provide adequate documentation of the program. The verbal description would reveal to non-programmers exactly what the program does, and it could be used for checking purposes. Moreover, it would greatly facilitate revision of the program weeks or months later.

Before closing, it might be well to mention one other area which may soon draw the attention of management, if it has not already done so. Much is currently being written and said about the ability of electronic data-processors to provide information to assist management decisions. One form this might take is the processing of files and records already stored in a high-speed medium. There are two important aspects of this type of job. First, time is of the essence; and I am speaking of the time from the original request to the time the results are turned over to management Second, it cannot be assumed that these requests could be anticipated in the sense that programs could be prepared ahead of the request. At the same time, programming costs cannot be exorbitant as such requests may be for one-shot jobs. Clearly, this is a challenge which could be met by an adequate automatic programming system.

Conclusion

In the short space of this paper I have tried to show why the techniques of automatic programming are important throughout business data-processing application of large-scale,

(continued on page 32)

COMPUTERS AND ENGINEERING EDUCATION

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Anyone who has attempted to make a change in an engineering curriculum is well aware of the multitude of problems. So many new ideas, methods, and machines have come to the fore, each clamoring for a place in the curriculum, that one is tempted to eliminate them all and return to the teaching of only "basic physical principles" and "fundamental engineering design", whatever that may mean. However, this ostrich in the sand attitude is not conducive to progress; one must somehow eliminate some of the traditional subject matter and introduce the new. (The reader is referred to the "Saber Tooth Curriculum"[1] for some other thoughts along this line.)

It is not the purpose of this paper to say what must be withdrawn from the curriculum but rather to suggest a new subject. An attempt will be made to show how the new idea can be used in conjunction with the traditional.

The large scale advent of automatic computing machinery into the field of engineering research and development warrants careful examination by engineering educators. In the aeronautical industry, and to a great extent in other areas, both analog and digital computers often confront the young engineer within the first few months of his new career. It seems reasonable, therefore, for him at least to have been introduced to this important tool during his undergraduate days.

The research and development groups in industry use both digital and analog computers. Perhaps it would be good to try to include something of each in engineering instruction. This naturally calls for both types of machines to be available for use by the undergraduate. Often this is not feasible for, even if computers of advanced types are located on the campus, they are employed exclusively in graduate instruction and research. This is especially true of digital computers; but, as will be shown, analog equipment suitable for instruction can be built (or bought) for a very reasonable sum.

In addition to providing some familiarization with computing machinery, the use of the analog computer provides an excellent means for emphasizing the similarity of systems, whether they are electrical, mechanical, or thermal, etc. The integration of many fundamental principles thus can be achieved in a fashion long sought by engineering instructors. The same can be said for many of the mathematical principles taught by the mathematics department but so frequently neglected in the teaching of other courses.

Every engineering student knows well (we hope) the relation F = ma, force equals mass times acceleration. If he has had a course in vibrations, he may be aware that

$$Ma = M\frac{d^2x}{dt^2}$$

and be able to write, with some understanding, the differential equation

$$M\frac{d^2x}{dt^2} + f\frac{dx}{dt} + Kx = F(t)$$

But few students, if any, are aware of the similarity between this and the electrical equation

$$L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt = E(t)$$

The less familiar form of the latter equation is obviously

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{1}{C}q = E(t)$$

which is identical mathematically to the mechanical equation.

Such lack of understanding, of which this is but one example, definitely restricts the creative work which an engineer might otherwise be able to do. The solution of a few problems, similar to those above, on the analog computer serves well to emphasize the mathematical similarity and brings to light again the usefulness of simple calculus and differential equation principles.

A not-so-incidental product of instruction in the use of the analog computer is the use of the notation and principles of operational calculus. In more advanced courses, the concept of the transfer function can be introduced and the analysis (and synthesis) of systems such as simple servomechanisms can be carried out. A system can then be simulated on the

computer and an experimental analysis of its behavior determined.[2] Examples of this will be given later.

The implication of the above is this: by use of the basic elements of the analog computer, a model of a system, any system under study, can be constructed and analyzed. Since the systems studied in undergraduate classes are usually simple, the number of analog elements is small, consisting of a few DC amplifiers and power supplies; some capacitors for integration; resistors for in put and summing uses; a few potentiometers and a recording galvanometer for the output. By proper selection of these elements, and flexible arrangements of them, valuable instruction in many areas can be given.

The stability of the equipment and the accuracy of the results are, to a great extent, dependent upon the quality of the components used. Leakage resistance in the integrating capacitors, or from various components to ground must be kept as high as possible, high compared to the input and feedback resistors which are usually of the order of .1 to 1 megohm. However, a little care in construction of the equipment and some selection of parts from commercial grade stock will provide usable equipment at minimum cost.

The cost of construction of manually balanced amplifiers can be kept as low as ten to fifteen dollars each, including student labor. Commercial units may be bought for around twenty dollars plus a small amount for the construction of racks into which they can be plugged. Stabilized power supplies to provide positive and negative DC voltage of the order of 300 volts can be built for about twenty to thirty dollars each.

While it is desirable to use potentiometers which are quite linear, and which can be adjusted to considerable accuracy (ten turn helical potentiometers), good results can be obtained with units costing a third as much if a large dial is used.

Multiple position, ganged switches make it possible to control several circuits with a fair degree of precision without the high cost of relays and requisite power supply. The switch contacts, along with the inputs and outputs of the amplifiers, the capacitor terminals, and so on can be connected to banana jacks on a patch panel of laminated plastic which can be engraved to show the circuit components involved. Spacing these jacks three-fourths inches increases the versatility of the system since this is the spacing of the General Radio double plug.

The overall cost of equipment of the sort described above and in sufficient amount to make it possible to work with second order differential equations can be kept under two hundred dollars. Additional elements, including non-linear components (diode limiters, etc.) are soon desired by anyone using the analog computer, and can be added as funds permit.

Problems similar to the following can be treated with minimum equipment and are sufficient to give the undergraduate student a look at the computer, familiarize him with the basic principles, and whet his enthusiasm for more information.

If one neglects the phugoid or long period oscillation resulting from forward velocity changes brought about by elevator deflection, the longitudinal characteristics of an airplane can be expressed by the following equations:

$$mv(\dot{\theta} - \dot{\alpha}) = L_\alpha \alpha$$

$$mK_y^2 \ddot{\theta} = M_\alpha \alpha + M_{\dot{\alpha}} \dot{\alpha} + M_{\dot{\theta}} \dot{\theta} + M_\delta \delta$$

where m is the mass of the aircraft; v is the airspeed; θ is the angle of pitch; α the angle of attack; Ky is the radius of gyration; L_α is the slope of the lift curve; δ is the deflection of the elevator; and M_α, $M_{\dot{\alpha}}$, $M_{\dot{\theta}}$, M_δ are the usual stability derivatives.

The equations can be combined into the form

$$A\ddot{\alpha} + B\dot{\alpha} + C\alpha = D\delta$$

where A, B, C and D are functions of the mass, velocity, and stability derivatives. By applying the Laplace transform, the transfer function relating α and δ can be shown to be of the form

$$\frac{\alpha}{\delta}(s) = \frac{K}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

when K, ζ and W_n can be calculated in terms of the airplane parameters.

The transfer function $\frac{\alpha}{\delta}(s)$ can be simulated by three amplifiers and three potentiometers as shown in Figure 1.

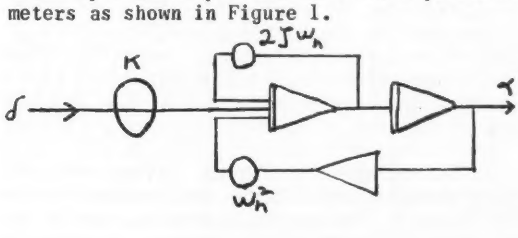
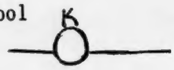


Figure 1

The symbol 

is a potentiometer set so that the output is K times the input, K being less than 1.

is an amplifier with capacitive feedback, thus is an integrator (with 3 inputs);

is an amplifier with resistance feedback used as an inverter only.

A series of runs determining α, for different δ inputs (step function, slowly increasing, etc.) and a number of values of the several parameters provides an interesting and valuable means of demonstrating the use of the computer and the relative importance of the parameters as well. A similar treatment can be made, relating lift to control surface deflection.

A simple analysis of the behavior of a series wound electric motor gives the following relationship between the angular velocity and the applied EMF

$$\frac{W}{E}(s) = \frac{.737K}{\left[s^2 + \left(\frac{R}{L} + \frac{B}{J}\right)s + \frac{.737K + BR}{JL}\right]}$$

$$= \frac{.737K}{\left[s^2 + K_1 s + K_2\right]}$$

where J is the moment of inertia of the armature
- R is the resistance of the motor
- L is the inductance of the motor
- B is the viscous damping effect of the armature
- K is the back EMF in volts per radian per second
- s is the Laplace operator.

This transfer function can be generated with the same three potentiometers and amplifiers used in the airplane problem above. With such a simulated motor, the effect of friction, moment of inertia, voltage and other changes upon the acceleration of the motor can be studied.

By adding an additional integrator, and sign changing amplifiers, and feedback as shown in figure 2, the system simulates a servo motor and follow up potentiometer. A number of interesting studies of the effects of parameter changes can be made with this system.

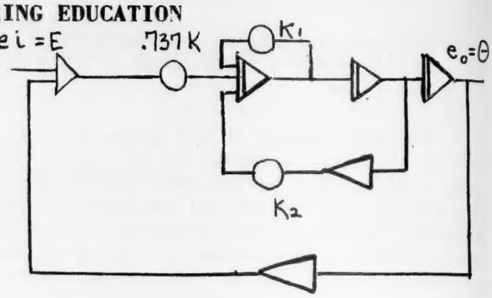


Figure 2

It will have the open loop transfer function

$$\frac{\Theta}{E}(s) = \frac{.737K}{s\left[s^2 + K_1 S + K_2\right]}$$

An excellent discussion of the simulation of electrical and mechanical systems, pointing up the similarity of the analytical treatment of these problems is given by Larrowe.[3]

Other examples of the use of the analog computer as a teaching aid, as well as a tool to be taught, will undoubtedly come to the mind of anyone who undertakes to use this versatile machine in his classes. It certainly is worthy of consideration when changes in course content and curricula are contemplated.

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1. Harold R. W. Benjamin, Saber Tooth Curriculum, McGraw-Hill, 1939.

2. Nixon, Principles of Automatic Controls, Prentice Hall, 1953, Sections 13.40 to 13.70.

3. Vernon L. Larrowe, Control Engineering, "Direct Simulation", November 1954: Vol. I, III; pp. 25-31.

- END -

THE PLANNING BEHIND THE I B M 702 INSTALLATION AT CHRYSLER CORPORATION

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Last summer the Chrysler Corporation became one of the first companies in the country to install a large-scale electronic data processing system entirely for commercial use, — in contrast to scientific or engineering use. This installation provides a good opportunity to examine Chrysler's experience in planning for and installing the system.

THE PRELIMINARY PLANNING

The decision of Chrysler to apply electronic data processing in its Parts Division came after an initial survey of its position in the highly competitive automotive industry. The survey, which began in October 1952, included a meticulous examination of all existing and proposed equipment. Then Chrysler invited International Business Machines Corp. and one other company in February 1953 to study the Parts Division for possible use of electronic data processing machines.

In order to conduct this study, Chrysler formed a new committee consisting of seven members. This committee was known as the E D P M Planning Group and included men familiar with digital computers, office procedures, and electric accounting machines. The first step by the planning group was to request from each department manager a written report describing the operation of his department. The EDPM Planning Group then reviewed and edited these reports and prepared a methods and procedures manual. The manual was completed in August 1953, and has proved to be a most effective way to educate persons working on the project. Besides, such a study is valuable in itself since it re-examines procedures within an organization. Because procedures have a tendency to remain static while the work to be done continually changes, review from time to time is essential to keep operations as profitable as they might be.

The Parts Division was particularly investigated and studied, in the light of the procedures outlined in the manual, and certain applications were selected which would apparently lead to an integrated system of operation through the use of electronic data processing machinery. In October 1953 possible programs were outlined and graphically illustrated with flow charts. Finally, preliminary phase was concluded by Chrysler's action ordering an IBM Type 702.

FINAL PLANNING

Four different plans were developed to provide the management of Chrysler with as wide a selection of action as possible. Each plan was complete in detail, with all supporting data and analyses included. Ultimately the management of Chrysler selected the following five basic applications:

(1) central inventory control; (2) central invoicing; (3) determination of cost of sales; (4) central accounts receivable; (5) sales analysis.

In order to make necessary changes in policy, reorganize departments, and convert procedures, a committee called the Executive Policy Committee was appointed. This committee consisted of all of the managers of the various departments affected by the project; its first step was to examine all of the proposed changes recommended by the planning group. Where policy and procedure changes suggested by the planning committee were not approved by the executive committee, a compromise between the two groups was reached.

The changes in policies and procedures were made official by the issuance of written procedures approved by the Division Comptroller and the Vice President of the Parts Division. By mutual agreement the application to central inventory control was selected in July 1954 as the first task to be assumed by electronic data processing machinery (EDPM).

CENTRAL INVENTORY CONTROL

In central inventory control, before mechanization, a certain "stock status record" made with bookkeeping machines reflected the activity which occurred from eight to twelve weeks prior to the posting. The processing cycle for this bookkeeping machine method was monthly. In order to prepare for EDPM, the operation was converted to a punched card system. The punched card operation summarized activity weekly and produced an Availability Report which indicated the status of inventory as of two to three weeks prior. Using the 702, the processing cycle of the present system has become daily: it reflects the inventory activity which has occurred during the preceding day.

This permits "management by exception," that is, isolation of those critical areas that need special and immediate personal attention out of a maze of 250,000 routine decisions each day.

Three basic tapes serve as input for the inventory control analysis. The first is the sales record tape which is a by-product of the central invoicing operation. The second tape contains all of the transactions except sales. The third is the master stock status ledger tape. The purpose of this particular run is to produce two reports and the updated master inventory ledger tape; these two reports will control the procurement and distribution of the inventory. The first is a stock status report, comprehensive and produced on an exception basis. Whenever this report is issued some type of action is required. It contains all of the information necessary to complete any action without reference to any other record. The second report or distribution report is used to allocate material due in at the central forwarding station for distribution to other warehouses, and to release back orders. Both reports are printed on a tape-to-printer operation with the output tape records generated by the 702 in this operation. The master stock status ledger tape is automatically updated as a result of this operation. That is, all indicative data that has changed and inventory status of each part are automatically recorded on the new master stock status ledger tape.

Once the machine has completely posted the stock status record for one part number the next job is to analyze the stock status report and decide if any action has to be taken on this item. In this program an average of twenty-four decisions must be made by the 702 for each part that has had activity. The average day's business includes ten thousand active parts. This means that 240,000 decisions -- business decisions, not program steps -- are made during the regular two-hour run each day.

The decisions fall into four basic categories:

(1) procurement; (2) distribution; (3) expediting; (4) disposition of surplus.

These are the four broad classifications of the type of decisions that the machine makes on each part every time it is active. The 702 completely watches all conditions and also checks the levels of stock and the demand being placed on outlying plants for parts. There are a number of different formulas for acquisition of parts depending on the distribution policy for the type of part, service ruling, or cost. The IBM 702 examines much of the heading data in the record and decides what parts of this data apply to the particular part being considered. The machine may even determine whether or not an item should continue to be stocked in a particular area where sales have declined. If the prerequisite conditions for stocking materials are not satisfied, the machine prints out a stock status report which tells management why the report was printed and what action is to be taken. A third type of review made by the machine is for follow-up action. If the current availability satisfies national and local requirements but the "on Hand" inventory is less than 60 or 30 days' supply for both requirements, then a stock status report is printed out and directed to the expediter for follow-up action.

The distribution report, the second report of this particular run, is also used for the allocation of parts received which are on back-order. The 702 automatically allocates the quantity to be used against back orders by date or age until the entire quantity is exhausted. Should it be necessary to make a partial shipment because the allocated quantity is not sufficient to cover all back orders, the 702 will automatically record this case. This particular record is maintained on the back-order summary tape. The quantity of parts on back order may vary from several hundred to a thousand. It is expected that this number will be greatly reduced through the daily control of inventory. To aid the back-order situation, a weekly customer shortage report of all back orders is also prepared. The historical data now being recorded on magnetic tape should be quite valuable in the future use of the 702 for comprehensive analyses of inventory and stock movements. This will enable management to exercise more precise methods in projecting future inventory movement.

CENTRAL INVOICING

The second application is central invoicing. To make this operation easier each warehouse has an installation of electric accounting (punch card) machines which prepare shipping orders. This enables shipments to be made ordinarily within eight hours after receipt of a customer's order. Notification of shipment is received from the shipping department, the cards which were used to prepare the shipping order are pulled, changes are made in the cards to indicate the exact quantity shipped, and correct shipment cards including name and address cards and data cards are forwarded daily by air express to the central invoicing center. A control card is inserted with each group of cards indicating the exact amount of sale for that group. When the cards are received they are automatically balanced to the control card and converted to magnetic tape.

The following output tapes are prepared as the result of the invoicing operation:

1. The invoice record, converted by a tape-to-printer operation, preparing the invoices.

2. The invoice register tape, converted by the printer, preparing the invoice register.

3. The sales analysis tape by product, by type of customer.

4. The accounts receivable tape.

5. Disbursements tape, discussed in the inventory control application.

6. Back-order detail for releasing back orders.

The invoicing operation is currently being performed with the use of electric accounting machines installed at five warehouses. When this operation is converted to the 702 and performed centrally it will reduce the work load in these five installations by 50%. Invoicing for the entire United States is done in two hours of 702 time with an additional 12 hours for the tape-to-printer operation each day.

COST OF SALES

The third application is cost of sales. Unit cost for each part is available on the master inventory ledger tape. Disbursements are extended to write a tape for cost of sales for the day's sales; then they are merged with the month-to-date cost-of-sales tape. At the end of the month the final cost of sales is printed on a tape-to-printer operation so that immediately after the close of the month's business the cost of sales for all sales for that period is available. This is an excellent example of the extensive by-product advantages that result from the integration of an operation of this type.

ACCOUNTS RECEIVABLE

The fourth application is accounts receivable. It is interesting to note that the major portion of Chrysler Accounts Receivable results from the sale of parts. These transactions are recorded on magnetic tape produced during the invoicing operation. The balance is key punched into cards and then converted to magnetic tape. The 702 is used for the sorting of the tape into dealer sequence for two groups known as the 85% group and the 15% group, and the two tapes are merged prior to the accounts receivable run. The remittance tape used as input is written at the time a statement is sent to a dealer or a customer. A prepunched remittance card is enclosed with the request that the card be returned with the remittance. Thus most of the cards are returned with no action being required in the way of key punching. However, four basic classifications have been established for handling remittances automatically or semi-automatically:

1. Complete cash payment with the complete discount honored.

2. Partial cash remittance with the discount.

3. Complete payment with no discount.

4. Partial payment with no discount.

The cards are then sorted to dealer number, merged with miscellaneous transaction and adjustment cards, and converted to magnetic tape. This tape becomes the input remittance tape. Each day the accounts receivable are made current by up-dating the master tape. As a result it is possible for the Credit Department to have a daily record of all accounts exceeding their limits.

SALES ANALYSIS

The fifth application is sales analysis. The various distributions and summarizations required for sales analysis are easily obtained on the 702 by reading the tapes into the central processing unit. Based upon this information a large number of distributions can be stored on the magnetic drum. A quarterly report is prepared by dealer and accounting class showing the amount of money, the number of orders by type of order, and whether it was a stock or emergency order. Accurate sales statistics for control of dealer sales are always available because of this operation. An annual report is prepared by warehouse and by states for all delivered parts.

CONCLUSIONS

This integrated data processing system has become a valuable tool for the management of Chrysler. The immediate advantages that the company may expect from the use of electronic data processing machines are these:

1. The major portion of all input information is available as the result of a previous automatic operation.

2. Management are able to use their time more economically, because the logical ability of the electronic data processor permits a discriminating selection of more critical problems for study.

3. Operation at high speed has been obtained.

(continued on page 32)

PUBLICATIONS FOR BUSINESS ON AUTOMATIC COMPUTERS:

A SUPPLEMENTAL LISTING

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This paper lists for business people what might be called a supplemental reading list of publications in the field of automatic computers. This listing is supplemental to the one published in "Computers and Automation" for Sept. 1955 with the title "Publications for Business on Automatic Computers: A Basic Listing." It is expected that this supplemental listing will be followed by a third paper with the title "Reference Listing."

The publications listed in this paper present additional points of view and additional information (as well as repeating much of the same information) on the same topics covered by the publications cited in the "Basic Listing." The publications cited in this supplemental listing are grouped by subject matter. Within each subject matter grouping, the publications are listed in approximate order of scope and depth of coverage, the more elementary being listed first, the more advanced being listed last. Items that are background material have been identified as such in the annotation.

Use of Computers in General

Walter H. Wheeler, "Wanted: A Revolution in the Office," Management Review, V 42, #12 (Dec. 1953), pp. 712-713

Tedious paperwork should be mechanized.

Lawrence P. Lessing, "Computers in Business," Scientific American, V 190, #1 (Jan. 1954), pp 21-25

An easy-to-read general introductory article.

Everett S. Calhoun, "The Challenge of Electronic Equipment," NACA Bulletin, V 34, Section I, # 10 (June 1953), pp. 1267-1279

A general introductory article.

Matt W. Boz, "You, Electronics, and the Brass," Papers of the Sixth Annual Systems Meeting (New York: Systems and Procedures Association of America, 1953), pp. 14-20

Some good suggestions from one systems man to another on investigating possible automatic computer uses.

P. B. Laubach and L. E. Thompson, "Electronic Computers: A Progress Report," Harvard Business Review, V 33, #2 (March-April, 1955), pp. 120-128

Cost savings are slow to appear from the use of automatic computers, this survey indicates. The article also re-emphasizes that to use an automatic computer requires a good deal of preliminary work.

C. E. Knight and C. H. Fawkner, "The Impact of Automation on the Company Organization," General Management Series Number 178 (New York: American Management Association, Inc., 1955), pp. 11-21

A computer will have an important role in automated plants, and organizational changes will have to be made to reflect that role.

William Bamert, "Making A Feasibility Study: Strengthened Management Control," Electronic Data Processing in Industry (New York: American Management Association, Inc., 1955), pp. 112-124

This article lists some of the advantages in terms of systems improvements that might be realized with the use of an automatic computer.

Paul Kircher, "The Gap Between the Electronics Engineer and the Accountant," The Controller, V 22, #8 (Aug. 1954), pp. 358-362, 374

Vocabulary and attitude are the causes of the gap; better communication between the two groups should be established.

James Gibbons, "Is Push Button Accounting Around the Corner?" Interal Auditor, V 11, #1 (March, 1954), pp. 44-53

A payroll example is given to help the author answer "not yet."

John H. Lindholm et al., Electronic Business Machines -- A New Tool for Management (Winchester, Mass.: John H. Lindholm, 1953), 47 pp. Also, in condensed form: "What Business Can Expect of Electronic Office Machines," The Office, V 38, #6 (Dec. 1953), pp. 81, 85-86, 89-90, 92

Automatic computers are not giant brains, but they can nevertheless still be used in business.

F. J. Porter, "EEI, Con Edison, and Electronics," Edison Electric Institute Bulletin, V 22, #12 (Dec. 1954), pp. 419-424

Describes the preparation these groups have made for the use of automatic computers.

Joseph E. Perry, et al., "ABA Report of the Committee on Electronics," Computers and Automation, V 3, #1 (Jan. 1954) pp. 10-12

The report suggest a rather conservative gradualism in adopting electronic equipment in banking.

Feasibility Studies

Radio Corporation of America, An Electronic Accounting System for a Medium Size Utility (New York: Radio Corp. of America, June 1953), 86 pp.

This is a summary of a feasibility study.

Ned Chapin, "Justifying the Use of An Automatic Computer," Computers and Automation, V 4, #8 (Aug. 1955), pp. 17-19

Expected savings must be balanced against increased investment in justifying an automatic computer.

Matt W. Boz, "Building a Checklist for Decision on Electronic Accounting," Office Management Series Number 131 (New York: American Management Association, Inc., 1953), pp. 9-13

Discusses some of the considerations important to an oil company in the possible appli-

cation of automatic computers.

John F. Feagler, et al., "Making a Feasibility Study," Electronic Data Processing in Industry (New York: American Management Association, Inc., 1955), pp. 74-124

A discussion of the Chesapeake and Ohio Railway Co.'s approach to the uses of an automatic computer.

R. F. Clippinger, "Economics of the Digital Computer," Harvard Business Review, V 33, # 1 (Jan.-Feb. 1955), pp. 77-88

Discusses in general terms the cost of operating an automatic computer.

Emerson F. Cooley, "Electronic Equipment Applied to Periodic Billing," Computers and Automation, V 2, # 8 (Nov. 1953), pp. 17-21

If a systems analysis can show that a cost saving will result, then the use of an automatic computer may be desirable.

Bernard Whitney, "How to Sell Accounting Systems," Systems and Procedures Quarterly, V 4, #4 (Nov. 1953), pp. 6-7, 22

Do not try to do it with the "accountant's" cost data.

Joseph O. Harrison, "Use of Computing Machines in Operation Research," Operations Research for Management (Baltimore: John Hopkins Press, 1954), pp. 203-216

Some interesting formulas are given to assist in comparing manual vs. computer methods of doing a task.

Charles I. Keelan, "Financial Decision," Office Management Series Number 135 (New York: American Management Association, Inc., 1953), pp. 24-31

Some interesting formulas are presented to assist in costing out a system.

Eugene L. Grant, Principles of Engineering Economy (New York: Ronald Press Company, 1950), 623 pp.

A background book; one of the best references on how to make a cost analysis.

Systems Analysis

Howard Aiken, "Preparing Students for the Automatic Office," Workshop for Management (New York: Management Magazines, Inc., 1955) pp. 341-348

The basic logic of business operations is not well enough understood to make the full potential of an automatic computer realized in business.

A. S. Householder, "Office Needs More Complex Computers Than Does Science," The Office, V41, #1 (Jan. 1955), pp. 82, 138, 140

The complexity referred to is not so much in the computers but is in understanding what business needs.

R. C. Ludlow, "Management in the Electronic Age," Journal of Machine Accounting Systems and Management, V 6, # 5 (May, 1955), pp. 8-10, 14, 16

Some thinking on the purposes of systems.

John M. Theis, "Practical Application of Electronic Equipment," Journal of Machine Accounting Systems and Management, V 6, #3 (March, 1955), pp. 5, 6, 8, 16-17. Also NACA Bulletin Conference Proceedings, V 35, #12 (Aug. 1954), pp 1732-1739

Avoid the mistake of simply mechanizing present procedures.

E. L. Morrison, "Making a Feasibility Study: Communication as an Element in an Integrated Data-handling System," Electronic Data Processing in Industry (New York: American Management Association, Inc., 1955), pp. 84-96

A minimum of information should be transmitted, but it must be adequate in content, form, accuracy, and timing.

Kenneth A. Wulff, "Planning for the Automatic Office--Consultant's Viewpoint," Workshop for Management (New York: Management Magazines, Inc., 1955), pp. 349-354

Attention should be given to systems changes.

Warren P. Livingston, "Where Do We Stand Today on Automatic Accounting Machines," Office Management and Equipment, V 15, #1 (Jan. 1954), pp. 24-26, 83-84

Not much of anywhere until systems and methods are standardized.

Ralph H. Eidem, "Review of Developments in Office Electronics," Office Management Series Number 135 (New York: American Management Association, Inc., 1953), pp. 3-9

Even though present equipment is neither ideal nor perfect, it can be used to advantage.

H. D. Huskey and V. R. Huskey, "New Frontiers in Business Management and Control Being Established by Electronic Computers," Journal of Accountancy, V 93, #1 (Jan. 1952), pp. 69-75

New equipment makes possible new systems.

David M. Brown, "Computer in the Factory," Computers and Automation, V 2, #7 (Oct. 1953), pp. 1-5

Potentially, an automatic computer can be applied to the control of production operations.

Joseph Pelej, "How Will Business Electronics Affect the Auditor's Work?" Journal of Accountancy, V 98, #1 (July, 1954), pp. 36-44

"Not much" this article suggests.

R. T. Wiseman, "Life Insurance Premium Billing and Combined Operations by Electronic Equipment," Journal of the Association for Computing Machinery, V 1, #1 (Jan. 1954), pp. 7-12

A discussion in some detail of a record modification application.

Melvin E. Davis and John J. Finelli, et al., Report of the Committee on New Recording Means and Computing Devices (New York: Society of Actuaries, Sept. 1952), 107 pp. Also condensed in: The Controller, V 20, #10 (Oct. 1952), pp. 465-469

Some useful guiding principles can be found in the middle part of this report.

Melvin E. Davis, "Some Current Thoughts on the Possible Uses of Magnetic Tape Policy Files in an Insurance Office," Electronic Data Processing in Industry (New York: American Management Association, Inc., 1955), pp. 217-230

A discussion of how systems using magnetic tape can be operated.

Harry Eisenpress, et al., "Charting on Automatic Data Processing Systems," Computers and Automation, V 4, #8 (Aug. 1955), pp. 21-23, 27

High-speed printers can be made to print out charts.

William R. Fair, "Analog Computation of Business Decisions," Journal of the Operations Research Society of America, V 1, #4 (Aug. 1953), pp. 208-219

Analog computers can be used to solve some Operations Research problems.

PUBLICATIONS

Human Relations

Devereaux C. Josephs, "AJEEB, the Mechanical Chess Player," Workshop for Management (New York: Management Magazines, Inc., 1955), pp. 336-340

An automatic computer need not and probably will not cause technological unemployment.

CIO Economic Staff, "Automation--A Report to the UAW-CIO Economic and Collective Bargaining Conference," Computers and Automation, V 4, #5 (May, 1955), pp. 14-20

Organized labor presents its reasoning about the changes that automation brings.

Examples of Applications

Richard G. Canning, et al., "Business Data Processing: A Case Study" Trends in Computers (New York: Institute for Radio Engineers, Inc., 1954), pp. 80-104

A discussion of a suggested application of automatic computers to retail operations. Some procedures are presented in considerable detail.

Robert M. Smith, "Is this a Blueprint for Tomorrow's Office?", Office Management and Equipment, V 16, #8 (Aug. 1955), pp. 12-14, 60, 64

Discusses the centralized data processing proposed at Sylvania.

Herbert O. Brayer, "How Five Major Companies Use the Electronic Calculator," American Business, V 23, # 11 (Nov. 1953), pp. 18-19, 41-44

Pennsylvania Railroad, Pure Oil, Illinois Bell, International Harvester, and Detroit Edison are the companies.

Fred E. Welsh, "What We Use Our Computer For," NACA Bulletin, V 36, Section I, #1 (Sept. 1954), pp. 31-36

Discusses the U. S. Gypsum applications.

William E. Eggleston, "Customer Accounting: Programming Methods and Problems," Electronic Data Processing in Industry (New York: American Management Association, Inc., 1955), pp. 190-196. Also summary in: Computer Application Symposium (Chicago: Armour Research Foundation, 1955), p. 7

A description of the Chicago Commonwealth Edison applications.

Mina Rees, Editor, Managerial Aspects of Digital Computer Installations (Washington, D. C.: Office of Naval Research, 1953), 36 pp.

A summary of the U. S. Government's experience in operating some scientific computers.

Jerry and Electra T. Kluttz, "Better Government for Less Cost," Nation's Business, V 43, #2 (Feb. 1955), pp. 38-41

A discussion of the U. S. Government uses for accounting computers.

J. Henry McCall, "Electronic Data Processing," Systems and Procedures Quarterly, V 5, #4 (Nov. 1954), pp. 12-16

Very little about computers here but some data on applying electronics to gathering input data.

Paul T. Nims, "Digital Computer Applications in the Automatic Industry," Proceedings of a Symposium of Industrial Applications of Automatic Computing Equipment (Kansas City, Mo.: Midwest Research Institute, 1953), pp. 146-162

Discusses engineering applications, not accounting applications.

K. D. Tocher, "The Application of Automatic Computers to Sampling Experiments," Journal of the Royal Statistical Society, Ser. B, V 26, #1 (Jan. 1954), pp. 39-61

Discusses a Monte-Carlo technique.

Integrated Data Processing

Harold F. Van Gorder, "Achieving Greater Productivity in Accounting Through Integrated Data Processing," NACA Bulletin Conference Proceedings, V 35, # 12 (Aug. 1954), pp. 1708-1731

Editor, "U. S. Steel Sets Up Automatic Office," Office Management and Equipment, V 15, #3 (March, 1954), pp. 24-27, 40, 74; V 15, #4 (April 1954), pp. 19-21, 29-30, 86, 88-91

Ralph W. Fairbanks, "Alcoa Inaugurates Integrated Data Processing on a National Scale," Office Management and Equipment, V 15, #12 (Dec. 1954), pp. 12-14, 32, 66, 68

Editors, "Integrated Data Processing Comes to Life," Automation, V 2, #5 (May, 1955), pp. 59-65

P. B. Garrott, "Integrated Data Processing Brings Automation in Paperwork," Automation, V 1, #5 (Dec. 1954), pp. 31-39, V 2, #1 (Jan. 1955), pp. 33-44; V 2, #2 (Feb. 1955), pp. 65-72

Ralph W. Fairbanks, "Integrated Data Processing for the Smaller Office," Office Management and Equipment, V 15, #6 (June, 1954), pp. 18-19, 78-80, 83

Robert M. Smith, "Automation in the Office," Office Management and Equipment, V 16, #1 (Jan. 1955) pp. 38-40, 65-68

Editors, "Integrating the Office for Automation," The Office, V 39, #4 (April, 1954), pp. 66, 68, 71

Harold F. Van Gorder, "Fundamentals of Integrated Data Processing," The Office, V 39, #4 (Apr. 1954), pp. 71-72, 75

H. W. Moore, "Data Origination," The Office, V 39, #4 (Apr. 1954), pp. 75-76, 84, 87, 89

L. W. Calkins, "High Speed Processing," The Office, V 39, #4 (Apr. 1954), pp. 79, 95-96

James Thomson, "Data Calculation and Distribution," The Office, V 39, #4 (Apr. 1954), pp. 78, 89, 92

R. W. Baridon, "Communication," The Office, V 39, #4 (Apr. 1954), pp. 80, 96, 98, 101

Computer Fundamentals

Louis N. Ridenour, "The Role of the Computer," Scientific American, V 187, #3 (Sept. 1952), pp. 116-130

A good discussion of the differences between digital and analog computers.

H. W. Steinhaus, "Keep Electronics in Mind When Planning for the Future," The Office, V 39, #1 (Jan. 1954), pp. 70-71

This article discusses history.

Philip and Emily Morrison, "The Strange Life of Charles Babbage," Scientific American, V 186, #4 (Apr. 1952), pp. 66-73

Some history on an important person in the development of computers.

Martin L. Klein, "Digital Technique and Binary Numbers," Instruments and Automation, V 27, #12 (Dec. 1954), pp. 1944-1947

A presentation of the binary system.

Beatrice H. Worsley, "Numerical Representation in Fixed-Point Computers," Computers and Automation,

V 4, #5 (May, 1955), pp. 10-13.
An understandable introductory article.

J. H. Felker, "Arithmetic Processes for Digital Computers," Electronics, V 26, #3 (March 1953), pp. 150-155
A discussion of arithmetic operations.

Vincent Petrucelly, "Boolean Algebra: New Tool for Circuit Designers," Electrical Manufacturing, V 54, #2 (Aug. 1954), pp. 97-101
A presentation of simple Boolean operations.

Robert Serrell, "Elements of Boolean Algebra," Proceedings of the IRE, V 41, #10 (Oct. 1953), pp. 1366-1379
A good but very technical article on Boolean algebra.

Programming

Grace M. Hopper, "Education of a Computer," Proceedings of a Symposium on Industrial Applications of Automatic Computing Equipment, (Kansas City, Mo.: Midwest Research Institute, 1953)pp. 139-144.
A discussion of programming aids, and the need for programming aids. This article is not a reprint of the author's other article with the same title, although much the same ground is covered.

Philip R. Marvin, "Engineering Automatic Systems," Automation, V 1, #4 (Nov. 1954), pp. 47-48
The writer addresses himself to the programming considerations.

Charles W. Adams, "Small Problems on Large Computers," Proceedings of the Association for Computing Machinery (Pittsburgh, Pa.: Richard Rimbach Associates, 1952), pp. 99-102
Discusses some programming techniques to help make small problems economically workable on an automatic computer.

Grace M. Hopper and John W. Mauchly, "Influence of Programming Techniques on the Design of Computers," Proceedings of the IRE, V 41, #10 (Oct. 1953), pp. 1250-1254
Programming and computer design go hand in hand.

Ida I. Rhodes, "The Human Computer's Dreams of the Future," Proceedings of the Electronic Computer Symposium (Los Angeles: Institute for Radio Engineers Professional Group on Electronic Computers, 1952), pp. XII:1 to XII:5
Interesting reading about what might come to pass.

Storage Devices

David R. Brown and Ernst Albers-Shoenberg, "Ferrites Speed Digital Computers," Electronics, V26, #4 (April, 1953), pp. 146-149
A presentation of ferrite storage devices.

Gilbert W. King, "A New Approach to Information Storage," Control Engineering, V 2, #8 (Aug. 1955), pp. 48-53
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- END -

AUTOMATIC MIXUP

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I.

Andrew Dunster, Chief Consulting Engineer of Natrasys, walked back into his little glass-partitioned office, leaving behind the sounds but not the sights of the great Central Control room. He was a tall man, in his early forties, a furry hairy man with thick black hair and a face that often smiled. It was not smiling now. A great pile of already opened telegrams was on his desk.

He picked up incoming telegram serial 14 and reread it:

> CENTRAL CONTROL, NATRASYS, NEW CHICAGO - CARGOLINER M239 OUT OF SAINT LOUIS FOR LOS ANGELES ARRIVED SEATTLE IN ERROR. REDISPATCHED. WHY CAN'T YOU MAKE YOUR XXX SYSTEM WORK?
>
> -- J. HUNTER, SEATTLE, 1215, 10 SEPTEMBER

He picked up another, serial 57, and reread it:

> CENTRAL CONTROL OFFICE, NATIONAL TRAFFIC MANAGEMENT SYSTEM, NEW CHICAGO - SPECIAL DELIVERY URGENT MISSILE G2418 OUT OF NEW CHICAGO FOR OZARKTON MO. WITH NOVOPOX VACCINE ARRIVED PROVIDENCE R.I. IN ERROR. REDISPATCHED AT ONCE. REQUEST CAREFUL CHECK EQUIPMENT.
>
> -- V. DONNELL, PROVIDENCE, 1309, 10 SEPTEMBER

The door opened, and Jim Hawker, Engineer-in-Charge of Natrasys, came in, a short, active, wiry little man, about thirty. Dunster turned half around from his desk towards Hawker, smiled faintly, and said, "Jim, how do we stand now -- what are we finding out?"

"Professor, Crew A has tested all the cables, and about 3/4 of the panel chassis. Crew B has tested about 60% of the tubes, titaniodes, and siliciodes. Crew C is checking insulation and is about 50% through. Crew D has checked the timing of all pulses, and about 80% of the magnetic and electrodynamic memories. Crew E ....."

"Yes, yes," said Dunster, smiling, "but what are we finding out?"

"Hell, Doc, that's just the trouble. Here and there we find some stuff that's a little below par. But we're finding nothing, nothing that can explain all this blazing mess," and Jim Hawker waved at the stack of telegrams.

"What about the trouble-shooting tapes?", said Dunster.

"We've run every Josophat one of 'em twice, Professor. Results — nothing. What's making our machine go wrong is intermittent. How I hate intermittent bugs, Josophat, how I hate intermittent bugs!"

"Yes, Jim," said Dunster smiling, "and how I wish that hating bugs got rid of them!" But before he had finished, his mind had detached from what he was saying and had gone puzzle-solving. He was looking unseeingly at the great rows of panels, signal lights, and equipment on the other side of the glass, filling a room that was nearly 200 feet square.

Dunster pointed at the heap of telegrams. "There are 382 complaints there, up to 1630 this afternoon. They began to come in around 1100."

Jim Hawker opened his mouth, but did not say anything, and shut it again.

Dunster said: "Jim, what does the Analysis Section have to say about the trends shown by these complaints?"

"I don't know Doc — I'll find out." Jim Hawker went out of the office.

The telephone rang. Dunster picked it up.

"Andy Dunster?"

"Speaking."

"Harry Eberhard, Andy. Have you located the trouble yet?"

"Not yet, Harry."

"Well, I'm coming out to see you right away."

"OK, we'll be here."

Dunster could tell that Eberhard was the opposite of delighted.

Dunster sat down at his desk, and his thoughts went back to his first conversation with Eberhard six years before.

II.

In June, 1986, Harry Eberhard, grizzled, short, in his forties, had entered Dunster's Computation Laboratory at Agamek University for the first time. He came in like a fresh breeze blowing papers around a room. With a big, smile, and rubbing his hands, he said:

"Professor Dunster, my name's Eberhard, president of the Sagamore Railway. I've heard you're interested in mechanical brains for automatic traffic control. I came down to Agamek this week on account of my son's graduation, and I thought I'd drop over and take a look around your laboratory, if I may. We ought to have some interests in common."

"I'll be delighted to show you around, Mr. Eberhard," said Dunster, "But suppose we call the equipment we're working with 'automatic machinery for handling information intelligently' instead of mechanical brains. Some people still object to that phrase."

So he had shown Eberhard around his laboratory, and then at the end, back in his study Eberhard, rubbing his hands and smiling, had said to him:

"Professor, by gosh, what you're doing is important. Your miniature automatic traffic controller is going to revolutionize the handling of traffic in this country. I can see it all. Just think -- no more wasted space -- no more traffic jams -- lower prices, in fact, really flexible prices. Why, the sky's the limit on what we can do. Human beings cannot know enough to handle 20 trillion shipments a year in the best possible way. But a machine can. Why, it's terrific!"

Dunster said: "Wait a minute, Mr. Eberhard. All we're trying to do is to show the feasibility of certain steps forward. There's always going to be some wasted space and time. But it's true that we can cut down the waste a long, long way."

Later, over scotch and sodas at the faculty club, before they separated, Eberhard had said: "Andy, we could go places -- your ideas, my business experience. We'd make quite a team."

On a moon-lit summer evening three weeks later, Eberhard was back, smiling broadly and rubbing his hands. He came into Dunster's study in the laboratory, fell into a deep black leather armchair and lighted a cigarette.

"Andy, I have been talking with quite a few businessmen, and some of them can see what I can see. We want to organize something -- we might call it National Traffic Management System, Natrasys. We will provide a service, a scheduling service. It will reach right down into the automatic loading and routing of vehicular space -- whether rail, air, truck, or ship."

Dunster puffed on his briar pipe, rubbed his thumb and forefinger reflectively on the thick stubble of his evening beard, and waited.

Eberhard went on with steadily increasing enthusiasm, "We shall traffic-schedule every vehicle that can hold freight. We shall begin around New Chicago, and expand gradually, but as fast as we can."

Eberhard paused. He got up. He looked straight at Dunster. "I want you to be in charge of making this thing come into existence. You've got the interest, the intelligence, the training. You're an engineer. I have visions but I don't have the training."

Dunster puffed on his pipe again before replying. "Harry, your enthusiasm is wonderful and your belief in my abilities is very flattering. But I want to be a scientist, Harry; that's what I'm cut out to be. My mission is to discover knowledge, to search for truth, to train students, to open windows for people who want to learn. I shall be a fish out of water in that scheme you're thinking of."

Eberhard sat down again and leaned forward. "Yes, Andy, I know. But I can promise you we shan't require you indefinitely. But without you we can't even start." He stopped and then went on again. "Besides your ability in the field of automatic machinery for handling information --" Eberhard grinned, "I'll try not to call them mechanical brains -- look what you've accomplished. You started out five years ago at Agamek, just an instructor. You were no professor. You had no laboratory. You had no building. You had not written any books.

"Now where are you? You're a full professor. You have your own laboratory in your own building -- oh, I know legally the building belongs to the University but actually it's yours, so long as you aren't convicted of moral turpitude. And you've written two books. And you have a department with three instructors working under you. And in your lab, you now have a miniature automatic traffic handling system, probably the best model for such a system in the United States.

"We need you not only for your scientific knowledge, Andy. We need you for your perseverance, and your intolerance of obstacles — the kind of special intolerance that gets them out of the way, and yet wonderfully enough, leaves people happy. How about joining us?"

Dunster said, with as much finality as he could manage to put into his voice: "I'm sorry.

I have to say no."

Eberhard just leaned a little further forward: "Look, Andy, you'd give us a lot of time and help -- for nothing, just for our asking -- you're that kind of a person. You'd give us that anyhow. What you don't want is to give up your laboratory, and give up all your time. Well, we'll not ask that. Suppose we build the headquarters of the National Traffic Management System on that land out there, right next to your laboratory." Eberhard pointed through the window northwards, into the moonlit evening.

"Over there on the other side," Eberhard pointed to the southwest, "will be the new Physics Center that Agamek is planning to build, the Radiation Laboratory, the Relativity Laboratory, the Nucleonics Laboratory, and the rest of them. Your Computation Laboratory, and the one and only Natrasys will be a fitting accompaniment to them.

"We'll make an arrangement with Agamek. You'll be right here in your lab, part of the time, and next door in Natrasys, part of the time. Your connection with Natrasys will give you far more funds, to develop your lab, and to steam ahead with, than you could get in any other way. Even today, scientific investigation does not get all the support it could use. You know you have to raise more money, more endowment, to keep pushing the things you've begun. Natrasys will solve that unsolved problem of yours -- will perhaps save you quite a slug of time in the long run."

It was Dunster's turn to get up and walk restlessly around the room. Then he came back and said, "Harry, you're very persuasive. Let me think it over."

Eberhard said, "Andy, you don't need to think it over. Say yes now. If you say yes, you will be doing something that will be very useful for great numbers of people -- ironing out the shipping and traffic jams that are gumming up so much of this society of ours. In addition, you'll have a big system instead of a baby one to play with -- I should say, to work with. Besides the practical problems of making a great artificial thinking system work ought to be of the highest scientific interest to you."

Dunster said laughingly: "You certainly know how to persuade people, Harry." He stopped. Then he said quite seriously: "I'm going to say yes after all, because your arguments are good ones. But let me warn you, Harry -- there are going to be quite a number of very rough places."

A few weeks later, Dunster took the suburban train into New Chicago, and met Eberhard in his office marked "President", on the 20th floor in the Sagamore Railway Building. Then they went together up to the Board of Directors Room on the 35th floor, a spacious room paneled with a great plate glass window, looking over the green parks and clean white buildings of New Chicago, the sunlight flashing on the water of Lake Michigan.

After Dunster had perceived the room, the window, and the view, he noticed a tall stout blond man, perfectly dressed, talking in a loud and raucous voice to half a dozen other men. Eberhard politely waited, then introduced Dunster to the stout man saying, "Mr. Valerian Crumwell -- Professor Andrew Dunster."

Crumwell said, in the same loud and penetrating voice, "So you are the man with the big idea! Glad to meet you, Professor Dunster," somewhat prolonging the word Dunster as if he were having a great deal of fun with it. Dunster was nettled, and was displeased with himself for being irritated over so trivial a thing. He had heard of Crumwell, extremely rich, clever moody, a man interested in the early stages of new ideas, but when some of the stages went wrong, a man who became sour and vicious. All this registered in his mind in a fraction of a second. Almost without a pause after Crumwell's remark, Dunster said, "Glad to meet you, Mr. Crumwell."

Eberhard was addressing the group: "Gentlemen, all of us are here now. Let's begin." They selected chairs and sat at the table; Eberhard said: "Gentlemen, I believe we have a remarkable opportunity to get in on the ground floor of an amazing new scientific development. As I've said to you individually, and want to say once more to you now, I'm convinced we're on the threshold of completely automatic handling of traffic and shipments — railroad, truck, air, ship. We can create a scheduling and directing service that will be far superior to what this world has ever seen."

Eberhard went on with many remarks and statements in the same vein, which Dunster had heard before, and which he was sure the others had heard before, but he felt certain that Eberhard knew what he was doing, that he was seeking to create a frame of mind in which he would get the yeses that he wanted from the men present.

Eberhard came to a point; "You've heard me say many of these things before, but I'm no authority. My field is not the engineering of traffic control. But we do have here in Professor Dunster a man who is an authority. Professor Andrew Dunster of Agamek University is world-famous in the field of automatic machinery for handling information. His specialty is equipment for automatic traffic control. He has agreed to be our chief consulting engineer.

Do any of you want to ask questions of Professor Dunster?"

"Yes," spoke up Crumwell. He turned to Dunster. "Mr. Dunster," and again he slurred the name in a derisive way, "Mr. Dunster, what evidence do you have that this old scheme of Harry's will work? and that we will make money out of it instead of losing our shirts?"

Dunster sat up a little straighter: "Mr. Crumwell, I don't want to bore you with a lot of scientific details, but let me give you some of the more important part of the evidence.

"Automatic machinery for handling information is the heart of automatic traffic control. For this kind of machinery to work well, you have to be able to do four things, do them quickly, and do them reliably."

"One, you have to have a way of putting shipping and traffic information into an automatic machine; two, you have to have a way of remembering it; three, a way of operating with it; and fourth, a way of getting that information out of the machine, fast enough and reliably enough so as to direct shipments and traffic. All of these processes have now had over 40 years of development. The reliability and speed in these devices is now upwards of 100,000 times that of a human being.

"For example, we now have equipment that uses pulses spaced one hundredth of a microsecond apart -- that is, a hundredth of a millionth of a second. These have been standard operating pulses for computing equipment for the last 20 years. Here is the speed we want and need for automatic traffic control.

"Let me give you one more example. We have almost unlimited information storage capacity, magnetic books, sheets of magnetic surfaces on which information is stored as an arrangement of magnetized spots. So information can be stored at the rate of a billion decimal digits in a cubic foot of space. We can read any desired item of information in about a hundredth of a second. This also has been demonstrated to be reliable over the last 20 years.

"Mr. Crumwell, there is no doubt whatever of the capacity of science to build and operate automatic traffic control equipment which is fast and reliable. It will be much faster and more reliable than human beings. All that we have to do is to put together established and proved devices, to solve a problem that is becoming more and more important. But we must not forget that some errors, some pieces of trouble, are inevitable, no matter how excellent the equipment.

Crumwell said in his loud voice, "Yeah, well, you say what they all say. Eberhard, does this man know what he is talking about?"

Eberhard said, "I believe he does."

Crumwell said: "How many of the rest of you think so?" Six of the other eight men said, "Yes, I do."

Crumwell said, "Sam, you did not say yes -- what do you think?"

Eberhard whispered to Dunster: "That's Sam Oliver, head of the 2nd International Bank, New Chicago office."

Sam Oliver said, "What I know about Dunster is hearsay, which however agrees in reporting Dunster to be an expert. But I know Eberhard, and if Eberhard is willing to give adequate security, I think we can go ahead with the first installment. After all, if we begin with New Chicago and environs, and make a success of that, then we can spread out."

Crumwell got up: "OK, Eberhard, let's begin with your Natrasys and I will loan two-thirds of the commitment for the first year and then we will see."

Eberhard got up, smiling and rubbing his hands: "Thank you, Mr. Crumwell. We're all going to do well." Crumwell nodded goodbye and went out in haste.

The meeting broke up. Dunster said to Eberhard: "How well do you know Crumwell?"

"Andy, not too well, but well enough. When he thinks he can make a dollar, and nothing has yet gone wrong, he is OK. Once we get started, we'll run on our own steam."

"Harry, I do hope you're right. I don't like him. Besides I don't think he even heard my remark about errors."

"Nobody really likes him, Andy, but he's useful."

The first year had gone unexpectedly well, but the team of Eberhard and Dunster did not finish with needing Mr. Valerian Crumwell. The more Natrasys grew, the larger became Crumwell's investment, less in proportion but greater in amount. And as usual he required ample security, in this case an extensive mortgage on Eberhard's Sagamore Railway. It took all the spellbinding that Eberhard could muster over his stockholders to keep that going.

For those first six years, that were now over, Dunster, with Eberhard's staunch backing -- when he was not distracted --, and with a fair amount of Crumwell's money, had worked

long hours with a fine crew of men.

They had built the principles of automatic control of traffic into intelligent machinery. From the first, the automatic traffic management service was a success, and it had spread rapidly in a wider and wider network out of New Chicago. On the campus of Agamek University, next to MacNeil's Computation Laboratory, the great Central Control office of Natrasys occupied the second floor of the Natrasys Building. Panels of the equipment overflowed into the third and fourth floors, with thick connecting cables. The machine — if indeed it could be called "a" machine -- was quite probably one of the most intricate and intelligent assemblies of automatic control machinery yet in existence.

There had been troubles from time to time. Usually, Valerian Crumwell found out about the trouble too, and then he raised a storm, each storm worst than the last one.

Once there was a connecting wire that was slightly loose, and swinging. Every now and then it would swing against a terminal that contained pulses with the value 6. Finally, the insulation on that connecting wire wore through at that point, and so every now and then a 6 would come into some calculation where it had no business at all. If it had not been for a caravan of army trucks that provided a considerable amount of ground-shaking for a half hour one morning, Dunster wondered how they ever would have found out about that trouble.

Another time, when the system was still small and the disruption was minor, there had been extensive random misbehavior, completely unexplained for about a day. Then Dunster correlated it with the aurora borealis and an unusually powerful solar magnetic storm. He had prevented similar trouble in the future by appropriate shielding of sensitive parts of the equipment.

Another trouble occurred when a new section of Natrasys equipment was built in Indianapolis. This trouble however was a "safe" one -- it never permitted the equipment to work right even once until it was removed. It turned out that one of the young ladies wielding a soldering iron had disliked the red-yellow-red color-coded resistors because of her anti-Spanish feelings, and had put in patriotic red-white-blue resistors.

Once, the new Radiation Laboratory to the southwest had been trying out some new radiation apparatus. Extra pulses were liberally sprinkled all through the Central Control Office. Dunster guessed this one almost at once because he had been thinking something like this might readily occur. He had liquidated this trouble by installing lead shielding in the Radiation Laboratory and in the Natrasys Building.

As a regular routine monthly test, Dunster had arranged that a Natrasys test crew would hunt for the newest radiation apparatus in any of the nearby Radiation and Physics Laboratory buildings once a month. They would lift up the shielding around the apparatus, direct a beam of radiation at the Natrasys building, and test to see if any pulses got through Natrasys shielding. The last thirteen monthly tests had been pulse-proof.

As a general measure to forestall trouble, Dunster had considered duplicating the equipment in Natrasys, and requiring that both of two twin pieces of equipment agree on the same information before it was released to some other part of the system to use. This was still too expensive for Natrasys so far.

But Dunster had installed another protection throughout Natrasys. This was that Natrasys would carry along a check on any piece of information equal to the sum of the digits and letters (letters having the values A 1, B 2 up to Z 26). For example, piece of information Y2254 would have associated with it as a check, the number 38, namely the sum of 25, 2, 2, 5, and 4. Any change in a single character would alter the sum, although a pair of compensating errors, such as an interchange of two digits, would not be detected by this protection. This had worked remarkably well, and enabled automatic elimination of a large number of errors.

III.

The telephone rang, and Dunster abruptly returned to the present. He picked up the receiver.

"Professor Dunster", said the guard's voice, "Mr. Eberhard has arrived, and is coming at once to your office."

As Dunster put the receiver down, Eberhard opened the door to the office, and came in. Dunster saw that Eberhard's complexion was a little ruddier than usual, and there was no smile on his face. Dunster concluded that Eberhard had had a couple of drinks, perhaps more.

"Andy, old pal," said Eberhard, "this jat mess has got to stop." But the tone MacNeil listened to was even less friendly than the words.

"Harry, old pal," said Dunster evenly "you can't want that any worse than I do."

"Well, why don't you stop it?"

"As a matter of fact," said Dunster, "it probably has stopped -- for now."

"What," said Eberhard, "you mean the trouble in Natrasys has stopped?"

"Yes," said Dunster, smiling, "the frequency of complaints was slowing down from 1600 to 1630, and after 1630 I think only one has come in."

"Well," said Eberhard, "so you fixed the trouble," and he began to relax and smile.

"No, we didn't detect the trouble. We had all our inspection crews testing the equipment, and then the trouble just ceased, died away. Furthermore,"since the trouble is no longer manifesting itself, I doubt that we can find it by testing, for all the equipment is again functioning perfectly."

"Yes," said Eberhard reflectively, "I can see that, but I feel as if I were in a nightmare."

"We can however examine and analyse the 383 complaints, and see what sort of thing they indicate."

"Well, it's your responsibility, Andy."

"You're right, Harry" said Dunster deliberately and looking at Eberhard intently.

Eberhard went on, "Crumwell was bothering me the other day. He said he was tired of monkeying around with us. We had rolled up a fine record, he said sarcastically, of eleven pieces of trouble in six years. We had lost something like a quarter of a million dollars as a result, he said, and he was tired, jat tired of us. He said one more piece of trouble and he was through, jat it, through." Eberhard added, "I hope Crumwell doesn't hear of the trouble today."

Dunster said: "But he's bound to, Harry. This is the worst piece of trouble we've ever had. I think we'll be sued for something like six million dollars, estimating an average of $20,000 damage for each of 300 cases."

"Oh, jat, jat, jat, jat," said Eberhard feebly.

Dunster smiled again, "Harry, you may as well set to work thinking of a better answer than that for your friend Crumwell when he gets on the phone tomorrow about this."

"My friend!" said Eberhard, "the hell you say. He's no friend of mine. I wish I'd never seen him."

"No, not really, because Crumwell gave us the start of Natrasys," said Dunster. "You can't make great advances without money to invest -- at least you can't often. Crumwell is still supplying most of our working capital."

Eberhard got up, paced to and fro in the room, and wrung his hands. Dunster watched him. Then he got up, put his arm around Eberhard's shoulders, and said, "Sit down, Harry; take it easy; we're a long way from being licked."

Eberhard sat down, stretched himself out, held his head in his hands as if it were aching and sagged like a pillow with no feathers.

Jim Hawker came back into the room. "Professor, here is your analysis. They promised it to me every few minutes, and so I waited. But Josophat, Professor, the wires, the complaints, have stopped coming in. Wha'd'you know?"

Dunster reached for the analysis, took it, sat down at his desk, and was lost in concentration.

Jim Hawker said, "Professor, excuse me, I might as well let the inspection crews go home, I suppose, it's 1820?"

Dunster looked up long enough to say: "Sure, Jim. But have one crew stay in watch quarters — you can never tell when our Josophat Bug will start gnawing away again."

Dunster found the analysis most interesting.

Almost all the complaints were misdirections, as if the clerks who had entered the original shipping instructions had chosen at random a wrong destination for an otherwise correct shipment. It was as if some drug had affected them causing momentary loss of consciousness. But how could any drug affect so many clerks at so many shipping offices?

He looked through the analysis sheets for the table that showed the geographical distribution of complaints according to shipping office. There was, it seemed, a definite tendency for complaints to concentrate according to size of shipping office on the following principle: the larger the volume of shipments from a shipping office, the greater the number of complaints. Another look showed that the shipping offices connected with the Second Central Office of Natrasys, on the West Coast in New Frisco, had produced no complaints. The equipment there had not been affected by the trouble. The trouble was definitely associated with the first Central Office, New Chicago.

The analysis also showed that all the defective shipments originated in the period 1012 to 1547 on 10 September.

Other than these indications, Dunster felt that the analysis did not show much, aside from the fact that his earlier estimate of loss was too high. The average claim for damage was going to be far less than $20,000. In fact, he would estimate it at 300 times $5,000, or one and a half millions. Even so, Mr. Valerian Crumwell was definitely not going to be pleased.

Dunster leaned back in his chair, turning possibilities over in his head. Eberhard's eyes were shut and his mouth was open; he was making little snoring sounds.

The next day Natrasys had no trouble. Due to some kind of miracle, which Dunster did not understand -- and which he felt he had no basis yet for understanding -- the equipment of Natrasys apparently worked perfectly.

But the third day, around 0940, as Dunster came into the Central Control room, from the corridor that connected with the Computation Laboratory, Jim Hawker came up to him and said, "This just came in, Professor," Dunster read:

> CENTRAL CONTROL, NATRASYS, NEW CHICAGO -- FARMER G. OTIS HERE CLAIMING $200,000 DAMAGES FOR 8,000 CHINCHILLIZARD HATCHING EGGS DELIVERED DEAD. SHIPMENT SCHEDULED EXPRESS DETROIT TO KALAMAZOO, LOST, FOUND AT MIAMI, RESHIPPED. WHY THIS ERROR? PLEASE ADVISE. URGENT.
>
> -- I. R. CONE, KALAMAZOO, 0920, 13 SEPTEMBER

"Crumwell will sure throw a fit if he hears about this," said Hawker.

"You are right, Jim," said Dunster. "But the wire does not say the time when this shipment left Detroit. Can you find that out?"

Hawker said, "Yes, I will," and started to walk down to the Analysis Section. But a minute later Hawker came back with two more telegrams. "IT, the Josophat IT," he said and paused, "has started again."

Dunster took the wires and read them: "Yes, Jim. The Josophat Bug -- Get the test-crews going again, Jim. Have them concentrate on the condition of the machine at the time when the faulty shipments took place. Or ask them to if they can -- it is an enormous number of microseconds in the past."

IV.

Valerian Crumwell was alone, and walking back and forth on the thick soft dull-red carpet in his office on the 45th floor of the Board of Commerce Building. It was a big room. His desk, a great walnut affair, was in the center of the room; over by one wall was a conference table large enough for a dozen men. There were windows on three sides of the room. Crumwell rather liked his room as a rule. But today, 13 September, he was in no mood to enjoy it. He had been out of the office yesterday, to play golf. But he had made a mistake in choosing a partner, and he had been beaten. He did not enjoy being beaten. He was deeply irritated.

His secretary opened the door and shrunk a little, trying to make herself smaller and less conspicuous. "Mr. Crumwell," she said timidly, "there is a long distance call for you from Kalamazoo, a Mr. Otis -- he said it was important -- he said he had to speak to you personally."

Crumwell said in his loud voice, "You told him I was in conference?" The little secretary tried to shrink some more, and said, "Yes, but he insisted it was urgent, that I interrupt you -- I did not want to do it, Mr. Crumwell. He said it was about your horrible National Traffic Management System and 8000 murders.

"What?" said Crumwell, "what -- 8000 murders? Give me the phone." But he reached over to the phone on his desk and picked it up. "Hello," he practically shouted into the mouthpiece, "this is Crumwell."

"Mr. Crumwell," said a thin high-pitched biting voice on the other end of the line, "Mr. Crumwell, your horrible National Traffic Management System has just murdered 8000 -- just think, 8000 -- of my precious chinchillizard eggs worth $25 apiece."

"What?" roared Crumwell, "how's that?"

"Mr. Crumwell, they were shipped yesterday from Detroit addressed to me. It takes half an hour by special delivery missile. Chinchillizard hatching eggs can stand motion and coolness for about two hours and then they die. Well, what do you suppose your horrible system did for me?"

"What?" shouted Crumwell.

"Well those 8000 precious eggs went to Miami, Florida, -- just think -- Miami instead of Kalamazoo, and got lost down there, and did

not get to me until about 0800 this morning, and every single one of my poor little chinchillizard eggs is dead." The voice wailed at the other end of the phone, and then it became a shout: "And I shall have you know, Mr. Crumwell, I shall SUE YOU FOR $200,000. I am going to hire the best lawyers in the Midwest, and George Otis of Kalamazoo will beat Valerian Crumwell of New Chicago."

"Mr. Otis," Crumwell shouted, "let me look into this, I'll call you back in an hour or two, just as soon as I can get to the bottom of this."

The voice said, "Do as you like, Mr. Crumwell. You are going to get a summons in just about three hours. And you are going to pay me $200,000."

Crumwell was galvanized into anger and activity. He buzzed three bells. At once two young men assistants and his secretary came into the room.

He shouted at his secretary: "Miss Dantzig, transcribe that last telephone conversation. And call Eberhard; get him on the phone -- I want to raise hell with him."

He shouted at one assistant: "Call the directors of Natrasys, get them all here in my office at 1200. We're going to have a showdown on this. Oh, and call Dunster; tell him to be here at 1230."

He shouted at the other assistant: "Take the transcription of that phone conversation from Miss Dantzig. Look up George Otis of Kalamazoo. Find out what you can about him. Also find out what is the value of chinchillizard eggs. Check our shipping agent in Detroit. Dig up the whole story."

The young man started to ask him a question. He shouted at him, "Don't you ask me any questions. Can't you see I'm busy? Figure it out for yourself -- you'll get the transcription."

Then he shouted, but more to himself than to anyone else: "That son of a gun, Eberhard, I told him to make that system work. What does he think we're trying to do?"

V.

The clock on Crumwell's desk showed a little after noon. All the directors of Natrasys were present. Crumwell's temper had hardly cooled off at all. He had just finished telling the account, as he understood it, of the 383 complaint telegrams of 10 September, and the 9 complaint telegrams of 13 September up to noon. Crumwell shouted: "And that's the story of the latest episode of this freak of nature, the automatic control of traffic, Natrasys. I've had enough."

Eberhard spoke up: "Gentlemen, we are doing our best to remove the present trouble. The best scientific talent in the country, the best computing machinery talent, are on our staff. Let's consider how often these errors happen. Figures have often been quoted here in our directors' meeting, and they show that the overall reliability and accuracy of Natrasys is far superior to what happens in human management of traffic. Of course, previously all the mistakes were scattered — here an office made a mistake, there an office made a mistake. The far greater number of mistakes were the responsibility of a far greater number of individuals. Now, all the mistakes are centralized too, and we are the victims of that. When our system works, and it works almost all the time, it works wonderfully well and most profitably for all of us."

Oliver spoke up: "Yes, Mr. Eberhard, that is just the trouble -- 'when'."

Crumwell roared: "Yes, we stand to be sued for $200,000 on dead chinchillizard eggs, and Eberhard, you yourself estimate six million dollars damage suits on the 383 telegrams of 10 September. If I wanted to throw my money down a hole, that would pay me more in the end than your blazing Natrasys."

Eberhard, stood up, no smile on his face, wringing his hands: "Gentlemen," he said, "Gentlemen, think what we have accomplished in six years. Think of the good records we have set. Think of the dividends we have paid: over ten million dollars in the last year alone. Suppose we did have to settle some claims last year to the tune of $800,000. That still leaves more than 90% of the dividend earned for us."

Oliver started to say something, but Crumwell's secretary opened the door, saying in a trembling voice: "Mr. Dunster has arrived. You said you wanted to know, Mr. Crumwell."

Crumwell shouted, "Get him in here."

Dunster came in, a little smile around his lips; he knew without being told what was happening. He saw the bleak expressions on all the faces, and rage and hatred on Crumwell's face. He enjoyed this. It was a battle, and he was sure of his ground, and his weapons.

Crumwell said with exaggerated politeness and sneering in his voice, "Professor Dunster," and bowed. Then he roared, "You know what your Natrasys has cost us in damages in the last four days?"

Dunster smiled, "As yet, nothing actually, but potentially about two million dollars."

Crumwell shouted, "How's that? I thought it was nearly seven million dollars."

Dunster said, "We have revised our estimates. I believe your figure is an old estimate. Also, I have been talking to our Traffic Claims Division. They believe that we'll be much better protected than before because of a recent Supreme Court decision."

Crumwell shouted, "What decision?"

"The Snyder vs. United States decision, which limited in several ways the liability of carriers. The United States was the carrier in that case."

Crumwell realized he was losing ground because his assistant had not dug up enough information, and so he shifted his attack. "Mr. Dunster," he shouted, "what's the reason for this trouble in the first place?"

"Mr. Crumwell, I don't know." Dunster smiled again.

"What, you mean to stand there, you grinning idiot, and tell me you don't know?" The roaring was louder than ever.

Dunster smiled again, and bowed slightly: "Sir, there are many things that a scientist does not know."

Sam Oliver smiled, and Dunster realized that he might be winning over a man whom he had not expected to win over. Crumwell realized that he was losing a man from his side, and got even angrier.

Crumwell shouted, "So you mean to tell me that you don't know what the trouble is, and we may lose a million dollars of damages each day, and you just stand there and say you don't know,"

Crumwell turned to Oliver: "What do you think?"

Oliver spoke deliberately: "It seems clear to me that we are trying to do too much, considering the present state of the science. It seems to me it may be unwise for us to try to go so fast, press scientific advances to the hilt of possibilities. Automatic traffic control may be a thing of the future, not the present."

Crumwell shouted, "In any case, I think, Dunster is the wrong man to have."

Eberhard in alarm put in: "Dunster! We can't fire Dunster. There isn't a soul in the country who can take his place."

Crumwell looked at Eberhard, and all the pent-up rage inside of him burst. He screamed: "You blithering-eyed son of a witch! I can't fire Dunster? Is that what you say?" He turned to Dunster, "You're fired. You hear that? You're fired. Beat it! Get out of here!"

Dunster grinned inside of his face but only the traces of it showed on the outside: "Well, Mr. Crumwell, since I am fired, how much will you sell Natrasys for?"

If ever the wind burst out of a balloon, so the wind went out of Crumwell. He had not expected this sort of a reply from Dunster. Why did Dunster say that? Maybe Dunster knew how to fix that trouble. Maybe Dunster already knew. Maybe Dunster knew a good thing when he saw it. Maybe Dunster was going to play him, Crumwell, for a sucker. Maybe just as soon as he, Crumwell, got out of Natrasys, there would be no more troubles in Natrasys! All these ideas left their traces on Crumwell's face, and Dunster watching closely realized that each idea he had meant to suggest, was present.

Crumwell said rapidly: "Do you think you can fix that trouble?"

Now Dunster felt sure he had won, and he said with contempt: "I can't fix it while I am here arguing with you."

Crumwell decided he needed more time to settle the goose of Natrasys, Eberhard, and Dunster. He said: "Gentlemen, I propose that we give Eberhard and Dunster until noon tomorrow to get rid of the present trouble. If not eliminated by then, I propose we sell Natrasys for scrap -- not to Dunster -- and foreclose on the Sagamore Railroad."

Oliver said: "I agree to your first proposal anyhow. Let us give them a little more time. But we certainly cannot afford to let all our profits, and reserves, and resources go down the sewer of damages."

VI.

Back in the main control room of Natrasys, all that afternoon and evening, Dunster and Hawker and the six test crews worked steadily, testing possibilities. Eberhard stayed around, asking a few questions, watching, saying over and over, "I wish I could do something." Nobody said very much to him, but treated him like a piece of furniture. Every now and then he went into the men's room and took a drink.

This night there was no moonlight. Outside

the windows were just stars; the clouds of the day had blown off. The evening wore on, and the clock showed a little after 2100. Finally Dunster said: "Now at last we have checked every possibility we can think of, haven't we, Jim?"

"Yes," said Hawker, "every test crew has checked all their assignments. The assignments -- you drew them up — cover the complete machine. The Josophat Bug is beyond me."

Dunster said, "Hell is a place where all the equipment and all the instruments are perfect, and nothing works right."

Eberhard said: "You fellows sure inspire me. I think I should have been an engineer, so that I could be so utterly baffled."

Another complaint telegram, the 15th one for 13 September, was at that moment handed to Dunster. He read it:

> CENTRAL CONTROL OFFICE, NATRASYS, NEW CHICAGO -- ARGENTOMYCIN CAPSULES ARRIVED, BUT ALMOST TOO LATE. CLARA HARTLEY AGED SEVEN JUST SAVED. SCHEDULED NEW YORK TO OGUNQUIT. ARRIVED VIA INDIANAPOLIS. REQUEST URGENT CHECK EQUIPMENT IN INTEREST OF MEDICAL DELIVERIES.
>
> -- L. SEGERSON, OGUNQUIT, ME., 2025, 13 SEPTEMBER

Dunster handed it to Eberhard.

Eberhard said: "I have been afraid of that kind of thing all along. Playing with life and death, that's what they'll say. And they'll harp on it, and harp on it, until we are all run ragged. I can't stand this anymore. I'm going out and get drunk."

Dunster said: "OK, Harry," and for once his disappointment in his friend showed, and he added, in a voice Harry couldn't hear, "I guess that's the best you can do."

Eberhard took his hat and left.

Dunster turned to Hawker: "Jim, you're all worn out. Go and lie down on the sofa in the waiting room, and catch some sleep."

"Is there nothing more I can do, Professor?"

"Jim, I'm not sure there's anything anyone can do."

Hawker went into the waiting room by the guard's desk. He stretched out like a loyal dog at his master's command, and fell asleep in less than five minutes.

Dunster was alone, except for the night operating crew on Natrasys, all busy at their usual tasks. He went back into his office. He was tired, discouraged, and sleepy. He reached into a drawer for his little box of nodzistopine, and took a pill. The sleepiness left him. His thoughts became like crystal in clarity and vividness. It was dangerous medicine, he knew, but he could take one about once in six months without ill effects.

He sat down at his desk. It seemed that Crumwell's face looked at him from the opposite wall, agleam with malice and hatred and victory. He could hear Crumwell shouting. He had until tomorrow to win. Then probably he was through.

Then Eberhard's face seemed to look at him, Eberhard's face before the events of the last year had begun to put so much wear and tear into it. He was fond of Eberhard; he liked Eberhard's ambition, his enthusiasm, his energy, his judgment of men, his risk-taking. Dunster was deeply sorry that his failure at diagnosing the trouble was causing so much worry for Eberhard. He said to himself: "If we could reduce the strain on Eberhard, he would snap back into his old fine, stimulating self."

Dunster knew he had to put these thoughts out of his mind. He must go over the problem. Compare the evidence. Analyze the possibilities. Ask what are the basic assumptions? Am I considering all of them?

VII.

Eberhard came into the Sagamore Railway President's office the next morning about half past nine. There in the visitor's chair he saw Dunster, smoking his old pipe, deep in the morning paper.

Eberhard cried: "Andy, what are you doing here?"

Dunster said, "Well, Harry, the trouble's all over."

Eberhard stopped. "I don't believe it. Miss Drury, show me the latest traffic complaints on the teletype." He looked through them quickly. "Andy, the last one is the Ogunquit one." He took a deep breath. "Andy, how do you know there won't be some more?"

"The cause of them is removed," said Dunster. "At least, I believe it is removed, and at any rate, we know the cause."

Eberhard was grinning and breathless, "Andy, you've done it again. Tell me the story."

Dunster smiled. He said, "Well, last night after you left and Jim went to sleep on the sofa, I went into my office, and took a pill, and asked myself, 'What are the basic assumptions?' I started analyzing. It was certain that we had most thoroughly checked everything that we knew about. So probably it was something new, not previously met.

"Now the trouble was certainly like a shielding trouble.

"I got the analysis out and looked it over again. The more I looked at it, the more it made me think it was as if shipment n had been connected to destination n+1. That, of course, would get by our check number verification and other automatic checks. What could do that? Extra pulses or delayed pluses, perhaps.

"But every extra pulse was stopped by our lead shielding. We verified that completely on 10 September and again on 13 September. Besides, none of our check equipment, our oscilloscopes, our master timing verification procedures, had revealed extra pulses.

"Well, if not extra pulses, then maybe pulses which were delayed or advanced a little in time. But how? But here again, none of our verification procedures had detected anything like that. But maybe our observation and testing apparatus would be affected by the same trouble, getting through shielding.

"Now, what can get through shielding? Pulses cannot. But gravitation, for example, can. What else besides gravitation? We live in a space-time continuum, Aha! Time can get through shielding. Now, we are working with pulses way down in the finest subdivisions of time -- hundredths of microseconds. Suppose time varied -- not much but just a little bit. Then we could get delayed or advanced pulses. Most of them would simply cause the equipment to produce an ordinary isolated random failure, and then automatic recalculation would send the shipment on its way with the chances of being completely correct. But every now and then the connection between a shipment label and the destination label would be spoiled. So, our theory would explain what has happened.

"Now, maybe the assumption that time is sometimes not uniform explains the trouble in New Chicago. But why would we in New Chicago suffer from it a little, and our second Central Office in New Frisco not at all? Well, I said to myself, would there be some source of time variation nearby? As soon as I asked the question, I guessed an answer. The Relativity Laboratory. Why didn't I think of it before? Anyhow, why not go over and take a look there?

"Well, it was then about midnight. I took my master key, and went into the Relativity Lab, and found a piece of apparatus I didn't know about. The engineering notebook on the bench showed that a visiting young Scandinavian scientist Olaf Nordstrom had built it, and that he was experimenting with apparatus for varying time.

"His experiment records correlated with the time of our troubles. His address was in the front of the notebook. I went over to his dormitory, waked him up, and talked with him. Very obligingly he got up and went back to the lab with me, and explained all that he was doing. He was simply astonished that the range of his apparatus had penetrated 500 feet to Natrasys; he turned it off and promised to consult with me henceforth, so as not to disturb Natrasys.

"So I went back to the Computation Laboratory, it was then 0200, and went to sleep peacefully."

Eberhard took a deep breath. He said: "Andy, you're amazing. I am going to call up our enemy, Valerian Crumwell. Here, listen in on the extension."

Eberhard picked up the phone, and after a minute: "Mr. Crumwell, Dunster has licked the Natrasys trouble. He tracked it down to some new experimental apparatus in the Relativity Laboratory."

Then Dunster heard the familiar voice shouting: "You confounded sons of witches, why the blazes don't you prevent that sort of thing ahead of time? OK, so it's fixed. So why the hell do you bother me?" Crumwell banged the receiver down.

Eberhard and Dunster looked at each other and grinned.

- END -

FUNCTION OF AUTOMATIC PROGRAMMING

(continued from page 9)

general-purpose computers. I have pointed out several problem areas, starting with the training process, through programming and coding, and ending with the continual revision of programs to meet changing conditions. I believe there is something to be learned by looking at the procedure of programming from beginning to end. We can think of the ultimate automatic system as comprehending the entire process.

It is useful and reasonable to attack separate parts of the process at the present time, and this is now being done by some groups. It is encouraging that some of the problems I have mentioned have been partially solved by one group or another. I hope that the problem of programming will be widely recognized as important enough to attract the attention and effort of those capable of solving it.

The widespread, economic use of general-purpose data-processing equipment may, in fact, depend intimately on the development of more efficient, much faster, and much cheaper methods of programming.

- END -

IBM 702 INSTALLATION

(continued from page 15)

4. The inventory is reduced to a minimum because the stock is controlled daily.

5. An additional increase of control results from the centralizing of the vast inventory operation.

6. Major reductions in the cost of the operation are achieved.

- END -

NEW PATENTS

RAYMOND R. SKOLNICK, Reg. Patent Agent
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Long Island City, N.Y.

The following is a compilation of patents pertaining to computers and associated equipment from the Official Gazette of the United States Patent Office, dates of issue as indicated. Each entry consists of: patent number / inventor(s) / assignee / invention.

<u>November 1, 1955</u>: 2,722,125 / George W. Siebengartner, San Diego, and Curtis S. Dugan, Ventura, California, and Dean E. Humbert, Dayton, Ohio / United States of America / A gyroscopic control system.

2,722,379 / Arthur F. Hayek, Pleasantville, New York / General Precision Laboratory Inc. / A rotary motion storage device.

2,722,601 / Gerard Jean Rene Piel, Paris, France / Societe d'Electronique et d'Automatisme, Paris, France / An electric impulse counting chain having a plurality of cascade-connected bistable trigger circuits individually operating as binary stages.

2,722,604 / Evelyn Steward Lansdown Beale, Stanwell Moor, near Staines, England / International Standard Electric Corp., New York, N.Y. / A signal responsive and integrating device.

2,722,605 / Robert L. Mills and Frank J. McDonol, Dallas Texas / Socony Mobil Oil Company, Inc. / A balanced phase discriminator.

2,722,630 / Maurice Charles Branch, Peter Morris King, and William Arthur George Walsh, London, England / International Standard Electric Corp. New York, N.Y. / A gaseous discharge tube counting circuit.

2,722,654 / Daniel J. Sikorra, Milwaukee, Wisconsin / Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin / A regulating system for maintaining a quantity substantially constant at any selected value within a predetermined range.

2,722,660 / John P. Jones, Jr., Pottstown, Pa. / United States of America / Apparatus for transforming a signal into consecutive pulse code groups representative of consecutive amplitude values of said signal.

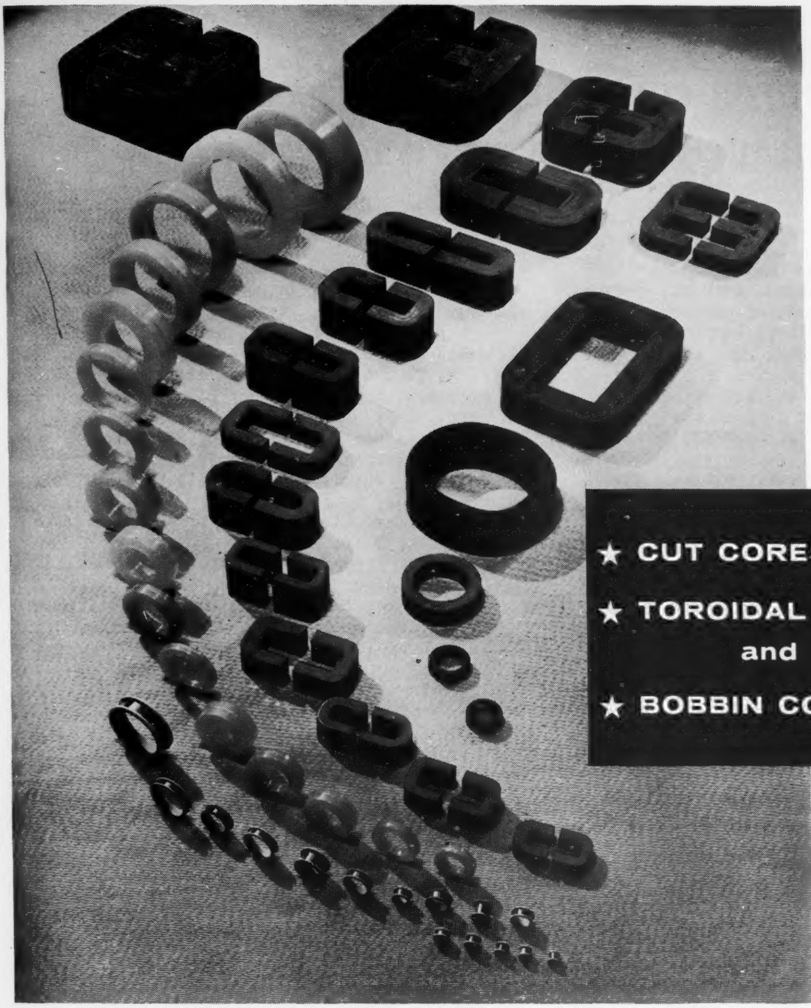
2,722,675 / Joseph Michal, New Hyde Park, and Robert E. Staehler, Ridgewood, N.Y. / Bell Telephone Laboratories Inc., New York, N.Y./ A pulse counting system.

2,722,676 / Semi Joseph Begun, Cleveland, Ohio / Clevite Corporation, Cleveland, Ohio / A magnetic information-storing device.

<u>November 8, 1955</u>: 2,722,845 / Clinton L. Cummings, Groton, Mass. / Barry Controls Inc., Watertown, Mass. / A change speed mechanism for instrument drives.

2,723,013 / Paul H. Rogers, Fort Walton, Florida,

(continued on page 38)



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ASSOCIATION FOR COMPUTING MACHINERY MEETING, PHILADELPHIA, SEPT. 14 to 16, 1955

Names and Addresses of Authors of Papers

In the November, 1955, issue of "Computers and Automation", we printed the titles, authors, and abstracts of the papers given at the meeting of the Association for Computing Machinery at the University of Pennsylvania, Philadelphia, Pa., Sept. 14 to 16, 1955. These titles and abstracts were reproduced photographically from the program distributed at the meeting; since the program did not give the authors' addresses, they were not printed.

This lack is now remedied. Following is the list of the names and addresses of authors, kindly furnished by Professor John P. Nash, Digital Computer Laboratory, University of Illinois, Urbana, Ill., chairman of the Program Committee of the Association for Computing Machinery. The numbers below agree with the numbers of the papers shown on pages 17 to 32 of the November issue.

1. David P. Perry, Sperry Rand Corp., 315 Fourth Ave., New York, N.Y.
2. Mark Lotkin, RCA Service Co., Inc., Missile Test Project, Patrick AFB, Fla.
3. Richard E. von Holdt, Radiation Laboratory, Univ. of Calif., Berkeley 4, Calif.
4. Wallace Givens, Dept. of Math., Univ. of Tenn. Knoxville, Tenn., or Oak Ridge Nat'l Lab., Oak Ridge, Tenn.
5. Robert Perkins, Ramo-Wooldridge Corp., 5740 Arbor Vitae St., Los Angeles 45, Calif.
6. Hollis A. Kinslow, IBM Corporation, P.O. Box 390, Poughkeepsie, New York
7. E. K. Blum, U.S. Naval Ordnance Lab., White Oak, Silver Spring, Md.
8. J. N. P. Hume, Computation Centre, McLennan Lab., Univ. of Toronto, Toronto, Canada
9. Charles E. Thompson, General Electric Corp., Richland, Wash.
10. John R. Stock, United Carbide and Carbon Corp., 30 E. 42nd St., New York 17, N.Y.
11. Stanley Frankel (Continental Oil Co.) 135 Main St., Seal Beach, Calif.
12. G. M. Amdahl and J.W. Bachus, IBM Corp., P. O. Box 390, Poughkeepsie, N.Y.
13. William E. Smith, North American Aviation Corp., 12214 Lakewood Boulevard, Downey, Calif.
14. Charles J. Swift, CONVAIR, San Diego, Calif.
15. W. R. Hoover, Calif. Inst. of Tech., Pasadena, Calif.
16. Norman Grieser, Underwood Corp., Electronic Computer Div., 35-10 36th Ave., L.I.C. 6, N.Y.
17. J. A. Postley, The Rand Corp., 1700 N. Main St., Santa Monica, Calif.
18. L. Eselsen, Remington Rand, Inc., 315 Fourth Ave., New York 10, N.Y.
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22. A. E. Roberts, Jr., General Kinetics, Inc., 555 23rd St., S., Arlington 2, Va.
23. Dean Arden, Mass. Inst. of Tech., Digital Computer Lab., Cambridge, Mass.
24. James E. Robertson, Digital Computer Lab., 168 Eng. Res. Lab., Univ. of Illinois, Urbana, Ill.
25. Norman R. Scott, Dept. of Electrical Engineering., Univ. of Michigan, Ann Arbor, Mich.
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27. Benjamin L. Schwartz, Battelle Memorial Inst., Cleveland, O.
28. R. L. Cline, IBM Corp., P. O. Box 390, Poughkeepsie, N. Y.
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41. Barry Gordon, Equitable Life Assurance Society, 393 Seventh Ave., New York 1, N.Y.
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113. Nyles V. Reinfeld (paper cancelled)Executive

(continued on page 37)

M A N U S C R I P T S

We are interested in articles, papers, reference information, science fiction, and discussion relating to computers and automation. To be considered for any particular issue, the manuscript should be in our hands by the fifth of the preceding month.

Articles. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words. A suggestion for an article should be submitted to us before too much work is done.

Technical Papers. Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable.

Reference Information. We desire to print or reprint reference information: lists, rosters, abstracts, bibliographies, etc., of use to computer people. We are interested in making arrangements for systematic publication from time to time of such information, with other people besides our own staff. Anyone who would like to take the responsibility for a type of reference information should write us.

Fiction. We desire to print or reprint fiction which explores scientific ideas and possibilities about computing machinery, robots, cyber-

(continued on page 37)

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(continued from page 35)

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114. Arnold Siegel, MIT, Cambridge, Mass.
115. R. E. Spero and J. Stuart, Sperry Gyroscope Co., Great Neck, N.Y.
116. J. K. Slap, Northrop Aircraft Corp., Hawthorne, Calif.
117. A. Karen and B. Loveman, Reeves Instrument Co., 215 E. 91st St., New York 28, N.Y.
118. Nathaniel Macon, Alabama Polytechnic Inst., Auburn, Ala.
119. R. S. Lehman and G. H. Weiss, Ballistic Research Labs., Aberdeen Proving Ground, Md.
120. W. F. Atchison, Georgia Inst. of Tech. Rich Computing Center, Atlanta, Ga.
F. T. Wall and L. A. Hiller, Jr., Dept. of Chemistry, Univ. of Illinois, Urbana, Ill.
121. J. Gardner, R. Page and O. Tiffan, Willow Run Research Center, Univ. of Michigan, Ypsilanti, Mich.
122. R. E. Utman and Margaret H. Harper, Remington Rand, Inc., 1624 Locust St., Philadelphia, Pa.
123. Anthony G. Oettinger, Computation Lab., Harvard Univ., Cambridge 38, Mass.
124. W. F. Bauer and A. Vazsonyi, Ramo-Wooldridge Corp., 5740 Arbor Vitae St., Los Angeles 45, Calif.
125. R. P. Beals, Chrysler Corp., Parts Div., 7000 E. Eleven Mile Rd., Center Line, Mich.
126. Louis B. Wadel and B. B. Mackey, Chance Vought Aircraft, Inc., P. O. Box 5907, Dallas, Tex.
127. Takeo Miura and Toshiro Numakura, Hitachi Central Research, Kokubunju, Tokyo, Japan
128. L. E. Heitzer, CONVAIR, Fort Worth, Texas.
129. M. Yanowitch, Reeves Instrument Co., 215 E. 91st St., New York 28, N.Y.

- END -

MANUSCRIPT NOTICE

(continued from page 36)

netics, automation, etc., and their implications, and which at the same time is a good story. Ordinarily, the length should be 1000 to 4000 words.

Discussion. We desire to print in "Forum" brief discussions, arguments, announcements, news, letters, descriptions of remarkable new developments, etc., anything likely to be of substantial interest to computer people.

Payments. In many cases, we make small token payments for articles, papers, and fiction, if the author wishes to be paid. The rate is ordinarily ½¢ a word, the maximum is $20, and both depend on length in words, whether printed before, whether article or paper, etc.

THE COMPUTER DIRECTORY, 1956:

NOTICE

The June 1956 issue of "Computers and Automation" will be the second issue of "The Computer Directory". Last year we published the first issue, 164 pages. Our present plans for the June 1956 directory follow:

Part 1 of the directory in 1956 will be a cumulative "Roster of Organizations in the Computer Field" based on the last cumulative roster (published December 1955, containing about 330 entries) and brought up to date. Entries in this roster will be free. If you know of any changes, additions, or corrections which should be made in the entries, please tell us.

Part 2 of the directory will be the second edition of "The Computing Machinery Field: Products and Services for Sale." Over 600 entries on 21 pages appeared in the first edition in June 1955; a considerable increase is anticipated. The previous entries, and blank forms, will be sent in February, to suppliers for review, checking, and additions. It is expected at this time that a nominal charge of $6.00 an entry will be requested from each supplier in order to help defray the cost of preparing and printing the directory; but if the charge is not paid, the entry may still appear in condensed form, if desirable to make the listing complete.

Part 3 of the directory will be the third edition of the Who's Who in the Computer Field. In the June 1955 issue, about 7500 entries appeared on 96 pages; of these about 2600 were full entries, and the remainder were brief entries. Our present plans are to publish only new or revised Who's Who information in the June 1956 directory. Blank forms for new or revised entries will be sent in February or March to all computer people we know of. It is expected at this time that a nominal charge of $2.00 an entry will be requested from each person whose entry is printed, in order to help defray the cost of preparing and printing the Who's Who; but if the charge is not paid, a brief entry may appear in condensed form if desirable to make the listing complete.

The main reason for the nominal charges mentioned above is that we look on the directory as a service to many people in the computer field; yet so far it has not paid for itself; and we need to make a compromise, publishing at least some information about everything that should appear in the directory, but fuller information for those who have shared directly in the cost.

SPECIAL ISSUES OF "COMPUTERS AND AUTOMATION"

The June issue of "Computers and Automation" commencing with June, 1955, is a special issue, "The Computer Directory."

For details about the next computer directory, see "The Computer Directory, 1956: Notice."

* ———————— * ———————— *

PATENTS

(continued from page 32)

and Richard H. Richwine, Greenfield, Indiana / - / An undirectional, one-way automatic spring clutch.

2,723,080 / Daniel L. Curtis, Venise, Calif. / Hughes Aircraft Company / A device, in combination with a bistable flip-flop, for rendering said flip-flop responsive to one of two input pulses applied simultaneously thereto.

2,723,081 / Harry B. Miller, Warwick, R. I. / Max L. Grant, Providence, R. I. / An overrun control for rotary-counter registers.

2,723,312 / John H. McGuigan, New Providence, N. J., and Orlando J. Murphy, New York, N.Y. / Bell Telephone Laboratories, Inc., New York, N.Y. / A magnetic drum dial pulse recording and storage registers.

2,723,347 / Louis F. Mayle, Fort Wayne, Ind. / Farnsworth Research Corporation, Fort Wayne, Ind. / A pulse keying circuit for a power amplifier.

2,723,352 / William C. Sealey, Wauwatosa, Wisc. / Allis-Chalmers Manufacturing Co., Milwaukee, Wisconsin / A polyphase regulating system for obtaining balanced voltages.

2,723,353 / Charles F. Spitzer, Syracuse, and Robert T. Gordon, Camillus, N.Y. / General Electric Co. / A non-linear resonant trigger circuit.

2,723,355 / Robert E. Graham, Chathorn Township, Morris County, N.J. / Bell Telephone Laboratories, Inc., New York, N.Y. / A diode gate circuit.

2,723,365 / Charles R. Williams, Hawthorne, Calif. / Northrop Aircraft, Inc., Hawthorne, Calif. / A sectional read-out tube and circuit.

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PUBLICATIONS

P 34; LINEAR PROGRAMMING AND COMPUTERS. Reprint of two articles by Chandler Davis, in July and August 1955 "Computers and Automation". A clear, well-written introduction to linear programming, with emphasis on the ideas. $1.20

P 2D: THE COMPUTER DIRECTORY, 1955. 164 pages, 7500 Who's Who entries, 300 Organization entries, and 600 entries of Products and Services for Sale in the Computer Field; 250,000 words of condensed factual information about the computer field, June 1955 issue of "Computers and Automation." $4.00

P 32: SYMBOLIC LOGIC, by LEWIS CARROLL. Reprint of "Symbolic Logic, Part I, Elementary," 4th edition, 1897, 240 pages, by Lewis Carroll (C. L. Dodgson). Contains Lewis Carroll's inimitable and entertaining problems in symbolic logic, his method of solution (now partly out of date), and his sketches of Parts II and III, which he never wrote since he died in 1898. ....$2.50

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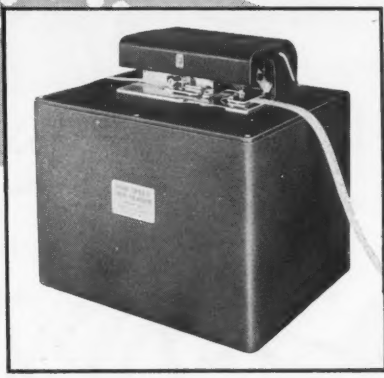

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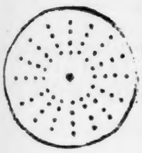

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Part 3: The Computer Field: Products and Services for Sale.
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Some Curiosities of Binary Arithmetic Useful in Testing Binary Computers — Andrew D. Booth
September: A Big Inventory Problem and the IBM 702 — Neil Macdonald
Publications for Business on Automatic Computers: A Basic Listing — Ned Chapin
Franchise -- Isaac Asimov
Automatic Coding for Digital Computers — G. M. Hopper
Automatic Programming: The A-2 Compiler System -- Part 1
October: The Brain and Learned Behavior -- Dr. Harry F. Harlow
Automatic Programming: The A-2 Compiler System -- Part 2
Who Are Manning the New Computers? -- John M. Breen
November: Automatic Answering of Inquiries — L. E. Griffith
Found -- A "Lost" Moon -- Dr. Paul Herget
Mister Andrew Lloyd -- R. W. Wallace
December: Digital Computers in Eastern Europe -- Alston S. Householder
Automatic Airways -- Henry T. Simmons
Roster of Organizations in the Computer Field (cumulative)
January, 1956: Machines and Religion -- Elliot Gruenberg.
Automatic Coding Techniques for Business Data Processing -- Directions of Development -- Charles W. Adams, Bruce Moncreiff
What is a Computer? -- Neil D. Macdonald

REFERENCE INFORMATION (in various issues):

Roster of Organizations in the Computer Field / Roster of Automatic Computing Services / Roster of Magazines Related to Computers and Automation / Automatic Computers: List / Automatic Computers: Estimated Commercial Population / Automatic Computing Machinery: List of Types / Components of Automatic Computing Machinery: List of Types / Products and Services in the Computer Field / Who's Who in the Computer Field / Automation: List of Outstanding Examples / Books and Other Publications / Glossary / Patents / Titles and Abstracts of Papers

BACK COPIES: Price, if available, \$1.25 each, except June, 1955, \$4.00. Vol. 1, no. 1, Sept. 1951, to vol. 1, no. 3, July, 1952: out of print. Vol. 1, no. 4, Oct. 1952: in print. Vol. 2, no. 1, Jan. 1953, to vol. 2, no. 9, Dec. 1953: in print except March, no. 2, May, no. 4, and July, no. 5. Vol. 3, no. 1, Jan. 1954, to vol. 3, no. 10, Dec. 1954: in print. Vol. 4, 1955, no. 1 to 12, in print.

A subscription (see rates on page 4) may be specified to begin with the current month's or the preceding month's issue.

WRITE TO:

Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
513 Avenue of the Americas
New York 11, N. Y.

2 ENGINEERS

ME or EE

DIGITAL COMPUTER DEVELOPMENT

Excellent opportunity to join an expanding, stable company, with an outstanding position in the precision electronic control industry.

Opening now available for an engineer able to assume responsibility for the development of complete systems for fire control and guidance, or major portions of such systems. Work will include research and development in the field of complex analog or digital computers.

A degree in electrical or mechanical engineering is required or the equivalent in experience.

MISSILE & WEAPONS CONTROL SYSTEMS STUDIES

Enjoy full use of your skill and imagination and friendly professional give-and-take with top men in the field of electro-mechanical precision equipment.

You will perform studies related to airborne weapons control and guidance systems with the object of determining requirements, feasibility, performance and specifications of computers and overall systems.

A degree in physics, ME or EE — or the equivalent in experience — is required. Must be able to handle problems in such diversified fields as digital computers, digital data transmission systems, logic counting and conversion circuits, high-precision gyro and gimbal structures, dynamic behavior of missiles, alignment of inertial platforms for guidance systems and fight evaluation of guidance systems and instrumentation. Send resume in confidence to

Technical Personnel Dept. 2-500

ARMA

Division American Bosch Arma Corp.
Roosevelt Field, Garden City
Long Island, N. Y.

Simulation Engineering

To conduct system studies on ROCKETS, MISSILES, and HIGH SPEED AIRCRAFT using the latest high speed digital computers and the most up-to-date analog computers.

Attractive opportunities exist for both experienced personnel and recent graduates in the following fields:

- **HIGH SPEED DIGITAL LOGIC**
- **AUTOMATIC CONTROL THEORY**
- **ANALOG COMPUTATION TECHNIQUES**

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Professional Employment

MARTIN

BALTIMORE 3, MARYLAND

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a montly magazine containing articles, papers, and reference information related to computing machinery, robots, automatic control, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $5.50 a year in the United States. Single copies are $1.25, except June, 1955, "The Computer Directory" (164 pages, $4.00). For the titles of articles and papers in recent issues of the magazine, see the "Back Copies" page in this issue.

2. What is the circulation? The circulation includes 2000 subscribers (as of Dec. 10): over 300 purchasers of individual back copies; and an estimated 2500 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the Jan. issue was 2500 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale.

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue. We reserve the right not to accept advertising that does not meet our standards.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" x 11" (ad size, 7" x 10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of a full page (ad size 7" x 10", basic rate, $190) two-thirds page (basic rate, $145), and half page (basic rate, $97); back cover, $370; inside front or back cover, $230. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $320; four-page printed insert (two sheets), $590. Classified advertising is sold by the word (60 cents a word) with a minimum of 20 words.

5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

Ampex Corp.
Arnold Engineering Co.
The Austin Co.
Automatic Electric Co.
Bendix Aviation Corp.
Cambridge Thermionic Corp.
Epsco, Inc.
Ferranti Electric Co.
Ferroxcube Corp. of America
General Electric Co.
Hughes Research and Development Lab.
International Business Machines Corp.
Lockheed Aircraft Corp.
Logistics Research, Inc.
The Glenn L. Martin Co.
Monrobot Corp.
Norden-Ketay Corp.
Northrop Aircraft, Inc.
George A. Philbrick Researches, Inc.
Potter Instrument Co.
Raytheon Mfg. Co.
Reeves Instrument Co.
Remington Rand, Inc.
Republic Aviation Corp.
Sprague Electric Co.
Sylvania Electric Products, Inc.

ROBOT SHOW STOPPERS

From time to time you may need to help organize a display in a business show including some device that you hope will "STOP" every person attending the show and make him notice your display — a device which may be called a "SHOW STOPPER".

In addition to publishing the magazine "COMPUTERS AND AUTOMATION", we have for five years been developing and constructing "ROBOT SHOW STOPPERS", small robot machines that respond to their environment and behave by themselves. Two of them are:

RELAY MOE: A machine that will play the game Tit-Tat-Toe with a human being, and either win or draw all the time, or (depending on the setting of a switch) will sometimes lose, so as to make the game more interesting for the human being;

FRANKEN: A mechanical rat that will explore a maze, find "food", and learn the path through; the maze may be set up by any person in the audience, using little partitions in any way that he wants to.

Besides these we have other small robots finished or under development. Some of these machines have been on the front covers of the magazines "Scientific American" and "Radio Electronics". These machines may be rented for shows under certain conditions; also, modifications of the small robots to fit a particular purpose are often possible, such as use of particular components, display of particular slogans, etc.

To: Berkeley Enterprises Inc.,
36 West 11 St., R143,
New York 11, N. Y.

Please send us more information about your ROBOT SHOW STOPPERS. The advertising application we have in mind is:________________

From: (Organization)

(Address)

(Filled in by: Name, Title, Date)

The most advanced developments in electronics are being made in the sphere of airborne radar and related ground control systems because of military emphasis.

Further applications of electromechanical techniques in these fields are creating new openings in the Systems Division of Hughes Research and Development Laboratories.

Engineers who have demonstrated ingenuity and inventive ability will find interest in areas of work that call for devising reliable, maintainable, manufacturable designs for precision equipment developed at Hughes Research and Development Laboratories.

The design of this equipment, manufactured at Hughes, involves mechanical, electromechanical, electronic, microwave and computing problems. Design also requires the use of such advanced techniques as subminiaturization, unitized "plug-in" construction, with emphasis on design for volume production. Knowledge of electronic components, materials, finishes and military specifications is useful.

SCIENTIFIC STAFF RELATIONS

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

ADVERTISING INDEX

The purpose of COMPUTERS AND AUTOMATION is to be factual, useful, and understandable. For this purpose, the kind of advertising we desire to publish is the kind that answers questions, such as: What are your products? What are your services: And for each product, What is it called? What does it do? How well does it work? What are its main specifications?

Following is the index and a summary of advertisements. Each item contains: Name and address of the advertiser / subject of the advertisement / page number where it appears / CA number in case of inquiry (see note below).

READER'S INQUIRY

If you wish more information about any products or services mentioned in one or more of these advertisements, you may circle the appropriate CA Nos. on the Reader's Inquiry Form below and send that form to us (we pay postage; see the instructions). We shall then forward your inquiries, and you will hear from the advertisers direct. If you do not wish to tear the magazine, just drop us a line on a postcard.

READER'S INQUIRY FORM

Paste label on envelope:↓

Enclose form in envelope: ↓

BUSINESS REPLY LABEL

NO POSTAGE STAMP NECESSARY IF MAILED IN

4¢ Postage Will Be Paid By —

BERKELEY ENTERPRISES, INC.

36 West 11th Street

New York 11, N. Y.

FIRST CLASS
PERMIT NO 1680
Sec. 34.9, P. L. & R.
NEW YORK, N. Y.

READER'S INQUIRY FORM

Name (please print)..............................

Your Address?..............................

Your Organization?..............................

Its Address?..............................

Your Title?..............................

Please send me additional information on the following subjects for which I have circled the CA number:

1	2	3	4	5	26	27	28	29	30	51	52	53	54	55	76	77	78	79	80	101	102	103	104	105	126	127	128	129	130
6	7	8	9	10	31	32	33	34	35	56	57	58	59	60	81	82	83	84	85	106	107	108	109	110	131	132	133	134	135
11	12	13	14	15	36	37	38	39	40	61	62	63	64	65	86	87	88	89	90	111	112	113	114	115	136	137	138	139	140
16	17	18	19	20	41	42	43	44	45	66	67	68	69	70	91	92	93	94	95	116	117	118	119	120	141	142	143	144	145
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REMARKS:

Mathematical Analyst Keith Kersery loads jet transport flutter problem into one of Lockheed's two 701's. On order: two 704's to help keep Lockheed in forefront of numerical analysis and production control data processing.

704's and 701's speed Lockheed research in numerical analysis

With two 701 digital computers already in operation, Lockheed has ordered two 704's to permit greater application of numerical analysis to complex aeronautical problems now being approached. Scheduled for delivery early next year, the 704's will replace the 701's.

Much of the work scheduled or in progress is classified. However, two significant features are significant to career-minded Mathematical Analysts: 1) the wide variety of assignments created by Lockheed's diversified development program and 2) the advanced nature of the work, which falls largely into unexplored areas of numerical analysis.

Career positions for Mathematical Analysts

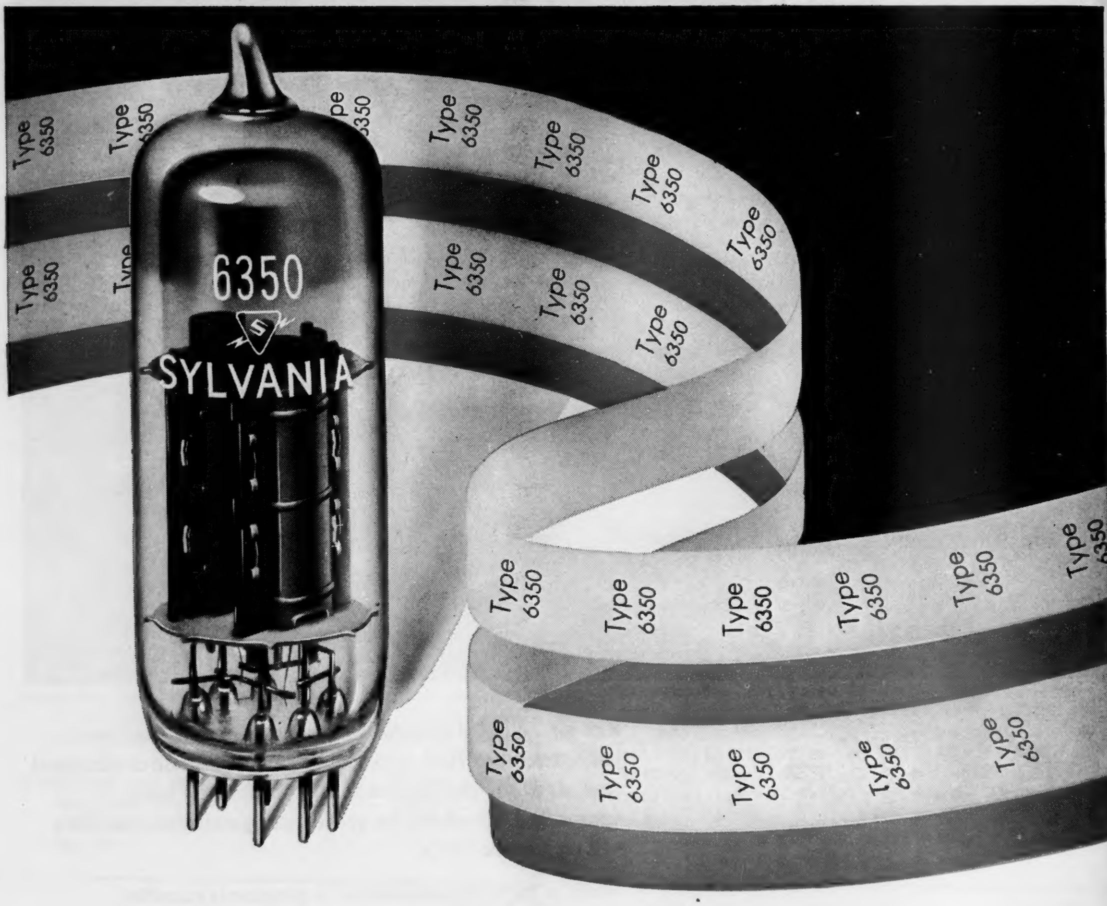
Lockheed's expanding development program in nuclear energy, turbo-prop and jet transports, radar search planes, extremely high-speed aircraft and other classified projects has created a number of openings for Mathematical Analysts to work on the 704's.

Lockheed offers you attractive salaries, generous travel and moving allowances which enable you and your family to move to Southern California at virtually no expense; and an extremely wide range of employe benefits which add approximately 14% to each engineer's salary in the form of insurance, retirement pension, etc.

Those interested in advanced work in this field are invited to write E. W. Des Lauriers, Dept. MA-31- 2.

LOCKHEED AIRCRAFT CORPORATION • CALIFORNIA DIVISION

BURBANK **CALIFORNIA**



More "soup" where you need it...

to drive magnetic cores, drums, computer read-outs

HERE IS a high perveance twin triode designed for heavy duty computer applications. It is capable of delivering peak cathode currents of 300 ma and will dissipate up to 7 watts.

The Sylvania type 6350 features separate cathodes for each section and controlled grid cutoff. Separate cathodes provide maximum flexibility in equipment design.

Cutoff is held to close tolerances facilitating the design of circuits for optimum cutoff signals. Minimum interface formation assures operation even after periods of extended cutoff.

DESIGN CENTER RATINGS FOR THE 6350

Peak Positive Plate Voltage (Abs. Max.)	1000 Volts
Peak Negative Grid Voltage	400 Volts Max.
Peak Positive Grid Voltage	13 Volts Max.
Peak Positive Grid Current	100 Ma Max.
Peak Cathode Current	300 Ma Max.
Plate Dissipation	
Each Plate	3.5 Watts Max.
Both Plates	7.0 Watts Max.

OTHER SYLVANIA COMPUTER TYPES

Type 5844	Medium mu triode
Type 5965	Medium mu twin triode
Type 6211	Medium mu twin triode
Type 5687	Low mu twin triode
Type 7AK7	Sharp cutoff pentode
Type 5915A	Dual control heptode
Type 6145	Sharp cutoff pentode
Type 6814	Medium mu triode

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In Canada: Sylvania Electric (Canada) Ltd., University Tower Bldg., Montreal

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

SEE SYLVANIA IN BOOTH NOS. 168-172 AT THE 1956 I.R.E. SHOW

Type 6350

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Volts
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Max.
Max.

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Max.

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